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TABLE OF CONTENTS.

LEADING ARTICLES: Page.

A Traveling Bridge Suspended from a Cableway for Making Fills (illustrated). 423
The Valuation for City Purchase of the Property of the Waterloo (Ia.) Water-Works Co.; A. Marston, M. Am. Soc. C. E. 424
A Large Dipper Dredge with Steel Spuds (illustrated). 426
Train Dispatching by Telephone on the Chicago, Rock Island & Pacific Ry.; F. W. Patherson 426
An Internal, Constant-Pressure Combustion Engine (illustrated); H. B. Stilz. 428
Sedimentation of the Water-Supply and Its Relation to Typhoid Fever in Washington, D. C. (illustrated); Francis F. Longley. 431
A Combination Retaining Wall and Quay. 433
The Reconstruction in Reinforced Concrete of the Large Manufacturing Plant of J. B. King & Co., Staten Island, N. Y. (illustrated); Arthur G. Hoadley. 434
A Skip for Cableways with Automatic Door for Dumping. 437
The Application of Spiral Hooping to a French Concrete Bridge (illustrated). 438
The Panama Canal and the Navigator. 443
Rock Excavation on the Atlantic Division of the Panama Canal. 444
A Complicated Reinforced-Concrete Jetty-Head, Thames Haven, Eng. (illustrated) 444
Specifications and Bids for a Refuse Incinerating and Power Generating Plant for Milwaukee, Wis. 445
The Proposed Addition to the New York State Barge Canal by Enlarging the Cayuga and Seneca Canal. 446
The Problem of Reducing Smoke on Railroads; Alfred W. Gibbs. 447
Comparative Tests of Large and Small Hammer Rock-Drills; J. B. Lippincott, M. Am. Soc. C. E. 449
Power Costs in a 1,250-KW. Central Station; H. S. Knowlton. 450
Notes from the Engineering Schools. 450

EDITORIAL. Page. 439

Road Improvement Plans and Policies in Pennsylvania and in Maryland—The Effect of Vibration on Setting Concrete—Surroundings and Grouping of Public Buildings—Further Light on Typhoid Fever and the Water-Supply of Washington, D. C.

A Criticism of the Reinforced-Concrete Bridge Truss. 440
The Milwaukee Refuse Incinerating Plant Specifications and Contract Award. 440
A Revival of the Constant-Pressure Internal-Combustion Engine. 441

LETTERS TO THE EDITOR. 441

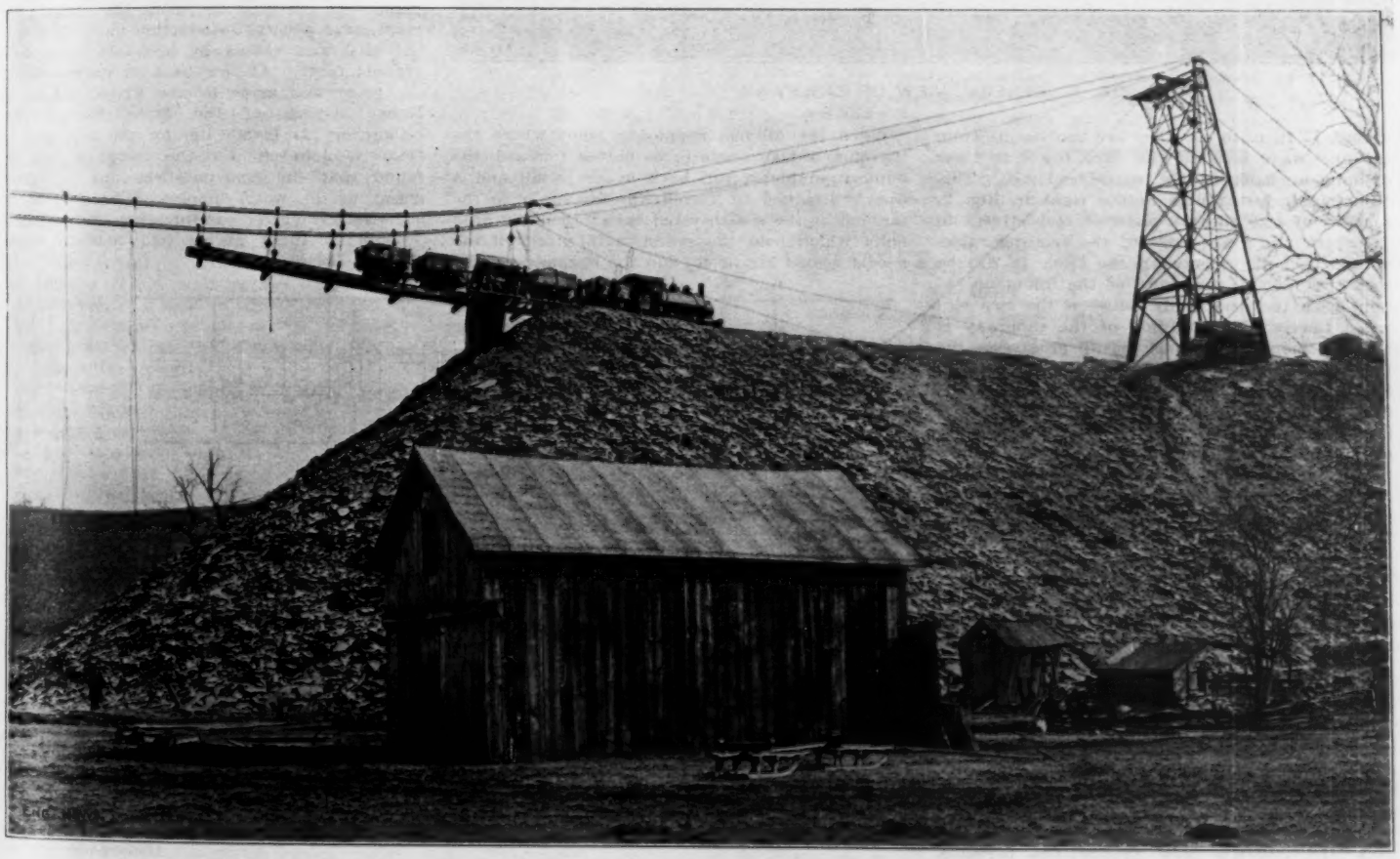
Professional Research and Editorial Iconoclasm; E. P. Coleman—Standard Methods for Bacteriological Examinations of Water and Milk; Alexander Potter—Waste of Water in New York City and Elsewhere; "2 Wall St."—Panel-Lengths for Equal Slope of Diagonals between Converging Chords (illustrated); Fred. McDonald—Subdividing an Arch Ring for Stress Analysis (illustrated); F. E. Turneaure—Proposed Water-Pollution Legislation in New York State; Palmer C. Ricketts—The Alien Labor Law and the Engineer; "Cosmopolite"—Notes and Queries.

ENGINEERING NEWS OF THE WEEK. 451
PERSONALS. 452
ENGINEERING SOCIETIES. 452

A Traveling Bridge Suspended from a Cableway for Making Fills.

In Engineering News, Oct. 10, 1907, p. 382, we recorded the use in the making of a fill on the Lake Erie & Pittsburg Ry. of a dump train running on a track hung from a suspended cableway. The outfits there used were somewhat primitive, but proved quite successful in solving the filling problem for the peculiar ground where they were installed. Since that time the idea has been developed and very successfully applied to a cableway traveling bridge which is being used in making a long and deep fill on the new Lake Hopatcong Cut-off of the Delaware, Lackawanna & Western R. R., which we described in our issue of Aug. 13, 1908, p. 176.

The apparatus herein illustrated is now in commission on one of the big fills of Section 5 of the Cut-off, near Blairstown, N. J. At this location the embankment is to be some 1,100 ft. long and about 80 ft. deep at its deepest point, and is being filled with shale rock hauled from a nearby cut on the same section. Fig. 2 will show the general type of the apparatus. Briefly, it consists of two towers, one fixed and one movable, between which a double cableway is suspended. From this cableway is hung a cradle, or traveling bridge, on which a 3-ft. gage track is laid. Beginning just inside the movable tower a construction track is started on the line of fill, on which the dump cars are pushed. As the fill progresses this track is extended out over its tailing, being suspended in this position from the aforementioned cradle, which is moved ahead with the fill. The front page view shows the track extending out over the fill and the cars dumping. As in the outfit described in our previous article, the cars are backed on to the track and each car is dumped as it reaches the end of the fill, so that the empties are always at the suspended end of the structure and the filled cars near the supports.



SUSPENDED CABLEWAY AND TRAVELING BRIDGE AT WORK ON D. L. & W. R. R. LINE, NEAR BLAIRSTOWN, N. J.

(Built by N. Y. Cableway & Engineering Co. Used on Contract of the Hyde-McFarlin-Burke Co.)

The fixed tower at the far end of the line is a standard cableway tower of timber, firmly held in place by the pressure of the cables and by its anchorage to the ground. It will not be moved during the entire construction. The movable tower is of structural steel 25 ft. long at the base and 20 ft. wide, tapering to a line 12 ft. wide at the top, which is about 70 ft. above the ground. The bases of the legs are covered with a horizontal plate which acts as a skidding base on which the tower is moved, when necessary,

along the 20-ft. gage track embedded in the fill. At the top the tower is provided with a specially designed saddle which takes the bend in the cable and also holds it firmly in place. All field connections of this tower are bolted together so that it is easily dismantled. Both towers are thoroughly guyed to the adjoining ground.

The cable and connections are shown on Fig. 3. These cables are 2¼ ins. in diameter and are spaced 12 ft. c. to c. They are continuous from the anchorage back of the fixed tower to their adjustment back of the movable tower. This adjustment, just visible to the right in Fig. 2, consists of two sheaves clamped respectively to the upper and lower ends of the slanting cable, with a take-up in between the two. It will be seen that at the beginning of the filling operation, with the deep gully between the two elevated towers, the deflection of the cableway is of small moment. But as the fill progresses the tops of the dump cars approach the cable until finally the tower has to be moved nearer the fixed end, and the slack in the cable thus caused is taken up between the two take-up sheaves noted. In this case the cableway has been loaded heavily at the far end so that it was raised at the fill end, thus extending the period of working before moving the tower became necessary. In Fig. 1 the operation has just about reached the limit of the position of the movable tower. Already five of the ten cars usually used have been taken off on account of lack of clearance, and these cars are being used to widen the fill so as to provide room for the moving of the tower. A short time after the photograph was taken, the tower was moved in.

From the 2¼-in. cables shown is suspended, by the detail shown in Fig. 4, the cradle on which the tracks are run. This detail comprises a 6-in. sheave, running upon the cable, and carrying the hanger cable. These sheaves and hangers are spaced every 12 ft. and are stiffened longitudinally by 4 × ½-in. iron bars. The end of the connected stiffener bars toward the movable tower is connected to a cable which extends to a sheave on the top of the tower and thence to a fixed end at the bottom of the tower. Since these stiffened hangers travel on the cableway on sheaves, they are free to move as a body and are controlled and kept at the proper tightness by this cable passing to the bottom of the tower.

Each hanger is adjustable in itself by means of the take-up pulleys shown in Fig. 4, so that the track can always be kept level and there will be no danger of the cars running down hill off the track. At their lower end, the hangers pass through a staple-bolt in the end of the so-called needle beams, that is, floor beams (Fig. 3). These needle beams are 8 × 10 ins. at the fill end where the loaded cars are and 8 × 8 ins. at the far end where the cars will always be empty. In turn these needle beams support, near the middle of the beams, the stringers, which, as shown in Fig. 3, are arranged in twos, toothing into each other at each needle beam so that there is a certain flexibility at each hanger. Upon the stringers are laid the ties and rails for the 3-ft. gage track.

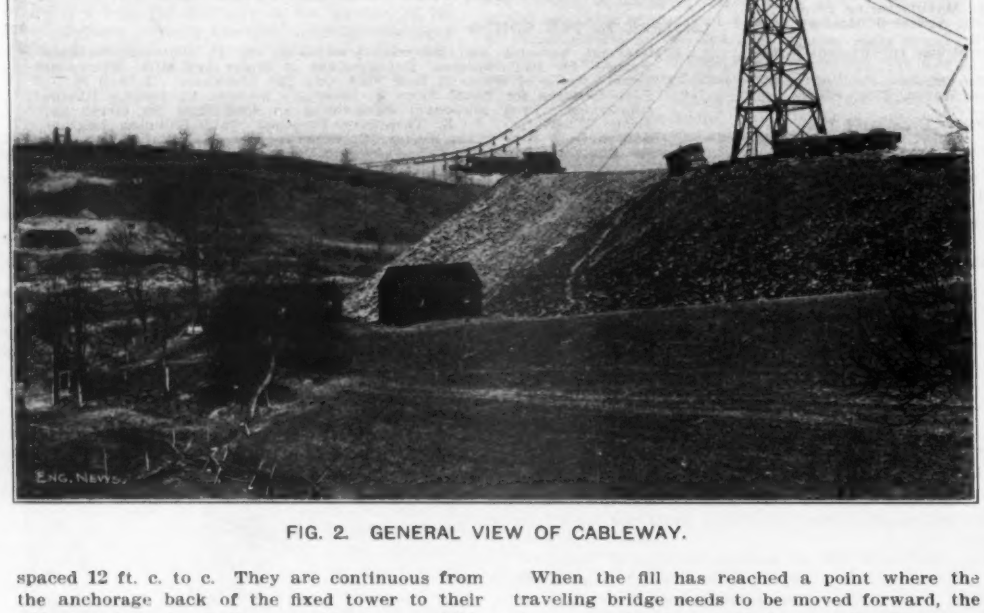


FIG. 2. GENERAL VIEW OF CABLEWAY.

When the fill has reached a point where the traveling bridge needs to be moved forward, the dummy engine is run back upon the fill and a line is attached to it from the far tower to the far end of the stiffener rod cable; then the drop bolts which hold the stringers in place on the needle beams are lifted, and the engine pulls the whole cradle or traveling bridge ahead to the proper place. The drop bolts are then fixed in their new position and the extension to the track built.

Fig. 5 shows an improvement on the cradle which the manufacturing company has now in process of construction. In this the iron stiffener bars are supplanted by cables which connect back to the controlling cable as in the present system, but in addition are guyed to the tower and the ground for stiffness. The needle beams in the new construction are inclosed in steel channels, as it has been found that the feeling stone from the dump cars cuts into the timber needle beams to a considerable extent.

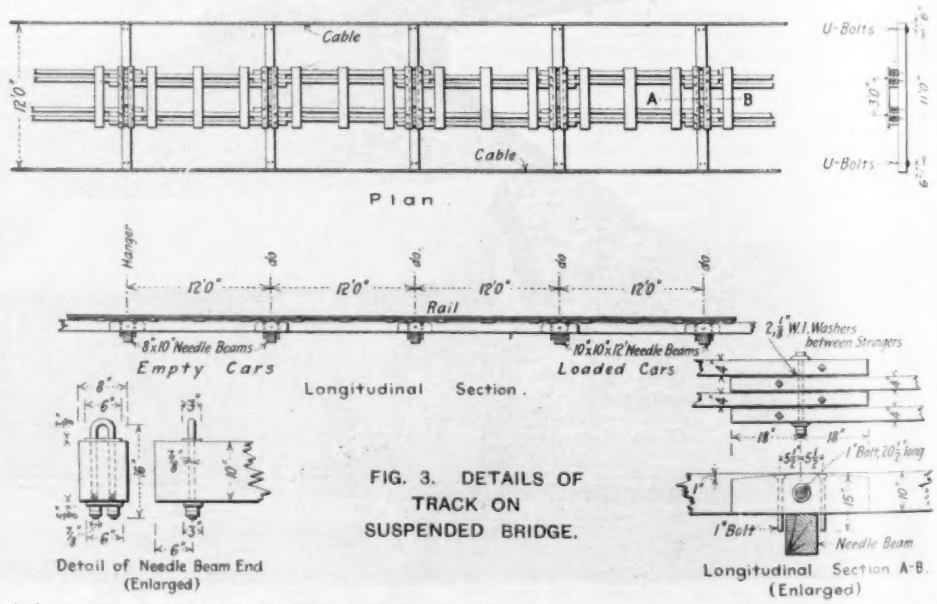


FIG. 3. DETAILS OF TRACK ON SUSPENDED BRIDGE.

The cableway at present is dumping 1,100 to 1,200 cu. yds. a day with no trouble whatsoever. Indeed, it could handle many times that amount, but is limited by the amount of excavation in the cut further back. The main points in its favor aside from its comparatively low first cost are the facility of operation and the almost total salvage value. No power is needed to operate it except the dummy engine that moves the cars, and when the work at any one place is completed the whole outfit is in shape to be transferred to any other location. The section on which the work is being done is under contract to the Hyde-McFarlin-Burke Co., of New York. The cableway was erected by the New York Cableway & Engineering Co., who hold the patent rights on the apparatus.

The Valuation for City Purchase of the Property of the Waterloo (Ia.) Water-Works Co.

By A. MARSTON,* M. Am. Soc. C. E.

The recent valuation of the property of the Waterloo Water-Works Co. furnishes another case where a fair valuation made entirely by the representatives of the city has been accepted by both parties as fair.

The city of Waterloo, in 1886, granted a 20-year franchise to the Waterloo Water-Works Co.† The company immediately constructed a plant consisting of a pumping station taking water from the Cedar River, a distribution system and a 15 × 85-ft. stand-pipe, on comparatively high ground. A Jewell gravity mechanical filtration plant was provided to purify the water. This plant gave general satisfaction until 1904, when the city was visited by a severe epidemic of typhoid fever. At this time an examination of the plant was made by the writer and by Dr. Henry Albert, of the State Bacteriological Laboratory at Iowa City, for the city, and Mr. Geo. A. Johnson, for the company. It was found that the epidemic was due to typhoid germs in the water-supply, as reported by the bacteriologist, after careful investigation. In all probability these germs had actually passed through the filters.

As a result of the engineer's report submitted at that time, the water-works company proceeded to sink two artesian wells, and at present obtain all the ordinary water-supply for the city, amounting to 1,500,000 gals. per day from these wells, the filters being held in reserve. The water is lifted by two Byron Jackson 15-in. deep-well centrifugal pumps, with a third in reserve. Two of the pumps are 5-stage and one is 3-stage. They are placed about 180 ft. below the

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†An earlier case was one in Illinois, in which Prof. D. W. Mead, of the University of Wisconsin, was one of three appraisers employed by the city alone. The water company accepted their valuation.

surface of the ground. One is located at the pumping plant and is driven by a simple Corliss engine belted to the vertical shaft of the pump. The other, located about ⅝-mile away, is driven by a belted electric motor without the presence of a regular attendant. These pumps are, in general, run night and day and have given good satisfaction, although twice an accident to the pump has required taking out the pump and shipping it back to the manufacturer for repairs.

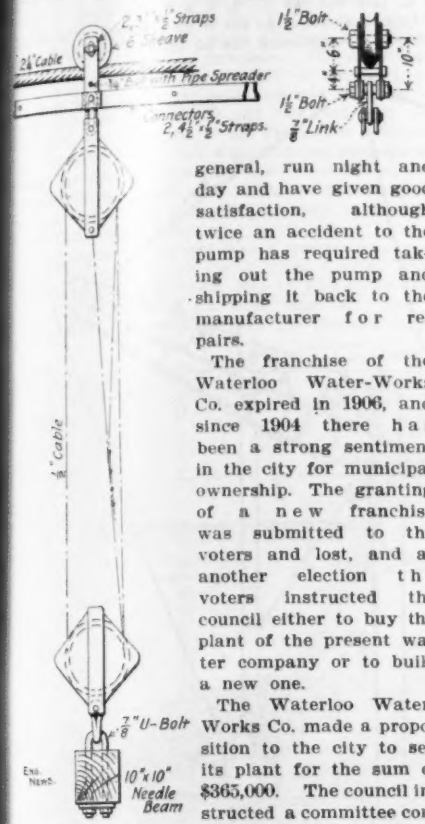


Fig. 4. Details of Hanger.

The franchise of the Waterloo Water-Works Co. expired in 1906, and since 1904 there has been a strong sentiment in the city for municipal ownership. The granting of a new franchise was submitted to the voters and lost, and at another election the voters instructed the council either to buy the plant of the present water company or to build a new one.

The Waterloo Water-Works Co. made a proposition to the city to sell its plant for the sum of $365,000. The council instructed a committee consisting of Mr. P. J. Rechfertig and Mr. C. T. Wilson, City Engineer, to make a valuation of the physical property of the company and report the same to the council. Authority was given to employ expert assistance, and the writer was engaged to act with the two men named in making the valuation of the property.

The city engineer prepared a list of the physical property, and from this list the writer made a physical valuation. This was taken to Waterloo and gone over item by item with the other two members of the committee, revising, slightly, some of the items. The completed valuation was then submitted to the council, together with an explanatory report by the writer. The total physical valuation amounted to $335,000.

This physical valuation and the explanatory report were published in full by every newspaper in the city. The feeling in the city over the question was intense at the time. The valuation was accepted unanimously by the council and by the city as a whole. I believe I am correct in stating that no criticism of any kind was made concerning its correctness either by the council or by the public.

Further, the valuation was accepted as correct by the company, and on it as a basis the company and the council agreed upon a price of $350,000, as a fair price for the property, making an allowance of $15,000 for "going value," nothing being allowed for franchise value.

The city engineer is preparing plans for extensive additions and improvements to the plant, and the council has voted to submit to the voters in the near future an issue of bonds sufficient to buy the plant and make the proposed improvements.

In Iowa, during recent years, there has been a rather general movement toward municipal ownership of water-works plants. In Ottumwa, Dubuque, Cedar Rapids, Council Bluffs and Des Moines, besides Waterloo, there has been much agitation of this question. In general, there has been serious conflict between the water-works companies and the cities.

In Des Moines, at the present time, a city ordinance lowering water rates is being fought by the water company in the courts.

In Council Bluffs, the city is considering the building of an entirely new and independent plant and has obtained authority from the Legislature to raise funds for this purpose.

In Cedar Rapids, there was tedious litigation in the courts in the course of which six valuations of the physical property of the company were made by four well-known water-works experts employed by the company and two by the city. The totals of these valuations of physical property, not including any allowance for "going value" or franchise value, were as follows:

For the company:	464,605	
	437,161	
	469,061	
	478,009	
Average		462,209
For the city:	300,592	
	274,168	
Average		287,380

[We append to Professor Marston's article an abstract of his "Explanatory Report on Valuation of Physical Property" and some references to his detail valuation statistics.

Professor Marston states that in making a valuation, well-established principles, as evidenced by court decisions in water-works cases, have been followed. These principles he summarizes as (1) finding the cost of reproduction of the physical portions of the plant; (2) deducting from this depreciation allowances; (3) adding to the result a "proper percentage to cover engineering, interest during construction, legal and general expenses, and contingencies." This result would be the present value of the physical property. To this third result a "going value" should be added, which Professor Marston defines as "the present worth of the excess of expenses over receipts necessarily incurred in the first few years of the operation of a new water-works plant until it can be put upon a paying basis." Finally, the franchise value is added. In the Waterloo valuation neither going value nor franchise value were taken into account. The franchise, it may be added, had already expired.

The prices adopted for cast-iron pipe and similar materials were the average market prices at the time of the estimate, plus 10% for contractors' contingencies. The average of five year prices, Professor Martson stated in his report, is more desirable in some respects than the current market price, but the latter is more in accord with court decisions.

The depreciation was calculated by the "sinking-fund method," in which it is assumed that a well-managed water-works plant will collect from its patrons and set aside annually, at compound interest in a sinking fund, an amount for each item of its plant sufficient to produce, at the end of the life of that item, a sinking fund accumulation large enough to entirely replace that item of property.

In the Waterloo valuation the probable life of each item involved, as well as its actual age at the time of valuation, was taken into account. Calculations were made by the aid of either a depreciation table published in "the last report of the Chicago Water-Works," or from depreciation curves like those published by Mr. John W. Alvord, M. Am. Soc. C. E. A sinking-fund interest rate of 2½% was taken.

For engineering, interest during construction, legal and general expenses, and all contingencies, a lump rate of 12½% was used, divided 5% each between engineering and inspection, and interest, respectively, and 2½% for legal and general expenses, general superintendence and contingencies.

Going value was left out of account in the Waterloo valuation, because access could not be had to the books of the company.

An allowance for taking up and replacing city pavements in the case of reproducing the existing plant was made, regardless of whether or not the original mains were laid before or after pavements were put down. This item was included in view of the general trend of court decisions.

The accompanying table shows the main items included in the estimate of physical valuation of property:

Group.	Classification.	Value new.	Present value.
1	Land	$20,400.00	$20,400.00
2	Wells, intake and suction	24,442.17	24,052.41
3	Reservoirs and stand-pipe.	9,251.60	6,016.66
4	Distribution system.....	145,887.91	135,983.71
5	Pumping-plant equipment	37,610.00	26,785.35
6	Filter-plant equipment...	21,899.00	14,668.90
7	Buildings and miscellaneous structures.....	27,480.15	24,319.28
8	Office furniture and appliances	924.50	566.00
9	Tools	445.00	250.85
10	Miscellaneous	305.00	199.75
11	Paving	43,355.72	41,621.49
	Total of Items 1-11....	$332,061.05	$294,864.40
12	Add 12½% for engineering and legal expenses, interest during construction and contingencies.	41,507.63	36,858.05
13	Stores and supplies.....	3,718.89	3,671.14
	Total physical valuation.	$377,287.57	$335,393.59

In the report the table given herewith was followed by others showing in detail how the estimate for each of the group of items was made up. Inasmuch as these details have little significance, unless they are accompanied by a full exposition of local conditions, we will not attempt to present them here.—Ed.]

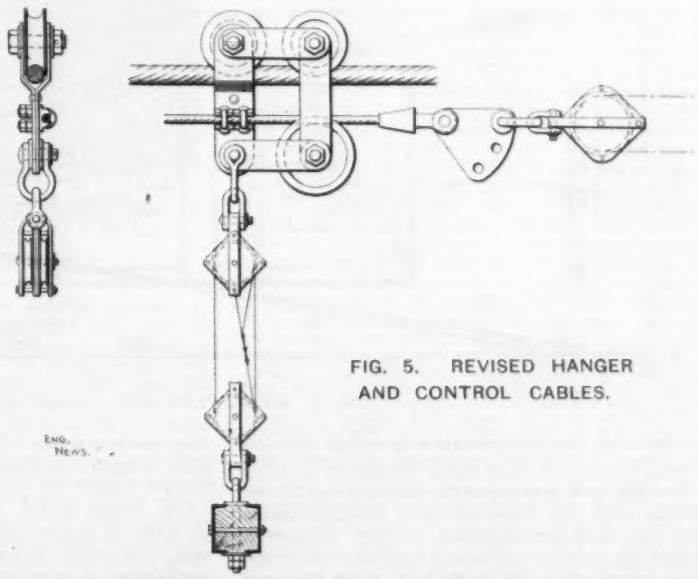


FIG. 5. REVISED HANGER AND CONTROL CABLES.

THE RECORD IN LARGE LOCOMOTIVES has again been raised, this time by two huge Mallet duplex compounds built by the Baldwin Locomotive Works for the Southern Pacific Co. The total estimated weight of the engine and tender is 600,000 lbs., of which 390,000 lbs. is on the 16 driving wheels. The boiler has a heating surface of 6,393 sq. ft. The principal dimensions of these locomotives are given by the builders as follows:

DIMENSIONS.

Cylinders	26 ins. and 40 ins. x 30 ins.
Boiler, diameter	84 ins.
Steam pressure	200 lbs.
Firebox, length,	126 ins.
Firebox, width,	78¼ ins.
Heating surface, firebox	232 sq. ft.
Heating surface, tubes	6,161 sq. ft.
Heating surface, total	6,393 sq. ft.
Grate area	68.4 sq. ft.
Driving wheels, diameter	57 ins.
Wheelbase, driving	39 ft. 4 ins.
Wheelbase, total engine	56 ft. 7 ins.
Wheelbase, total engine and tender	83 ft. 6 ins.
Weight, on driving wheels, est.	390,000 lbs.
Weight, total engine, est.	430,000 lbs.
Weight, total engine and tender, est.	600,000 lbs.
Tank capacity, water	9,000 gals.
Tank capacity, oil	2,850 gals.

A Large Dipper Dredge with Steel Spuds.

During the past year the Cuban government has had in service an 8-yd. dipper dredge, the "Cayo Piedra," fitted with built steel spuds instead of wooden spuds. They are reported to be working very successfully. The special feature to which the good results are ascribed is the arrangement of timber cushioning or crushing blocks between the spud and its seating in the hull. Thereby the spud is made less rigid, i. e., more elastic, approximating to the elasticity of the usual timber spud; at the same time the cushioning blocks distribute the bearing pressures on the steel member, avoiding the concentration of load on a small number of rivets.

The picture Fig. 2 herewith, showing the dredge viewed from the front while at work, indicates the size and arrangement of the cushioning blocks on the front spuds. A hinged cast-steel yoke surrounding the spud, just below the level of the deck, holds and encloses the timber blocks. At the bottom of the hull there is a similar yoke around the spud. These front spuds are 40 × 40 ins. in section and about 50 ft. long. They are made up of plates and angles, stiffened to resist the loads which come on them, and are handled by 2-in. steel ropes. The rear spud is similar but smaller, 30 × 30 ins., handled by 1¼-in. ropes. The spud ropes are handled by drums on a transverse shaft which passes across the whole width of the deck and is journaled in the frame of the main engine at its center, where it forms the intermediate gear shaft between the crankshaft and the 48-in. hoisting drum.

Fig. 1 gives plan and sectional elevation of this dredge. The simplicity of the machinery arrangement is apparent. The main engine, a double 17 × 20-in., operates the hoisting rope and the backing rope of the dipper, besides the spud ropes, as already noted. A separate double-cylinder 9 × 9-in. engine swings the boom. The hoist is direct, and the hoisting rope is double, consisting of two 2-in. ropes, equalized around a thimble at the dipper and winding up on opposite ends of the drum.

This dredge has an all-steel hull, 125 ft. by 42 ft., 12 ft. deep at the front end and 10½ ft. deep at the stern. There are two longitudinal steel trusses, entirely below deck level. The superstructure has timber framing.

The "Cayo Piedra" worked during the season of 1908 in depths of 32 ft., digging hard clay and rock, and the steel spuds are in excellent condition. It was built by the Atlantic Equipment Co., of New York., to designs of Mr. A. W. Robinson, M. Am. Soc. C. E., for the Department of Public Works of Cuba.

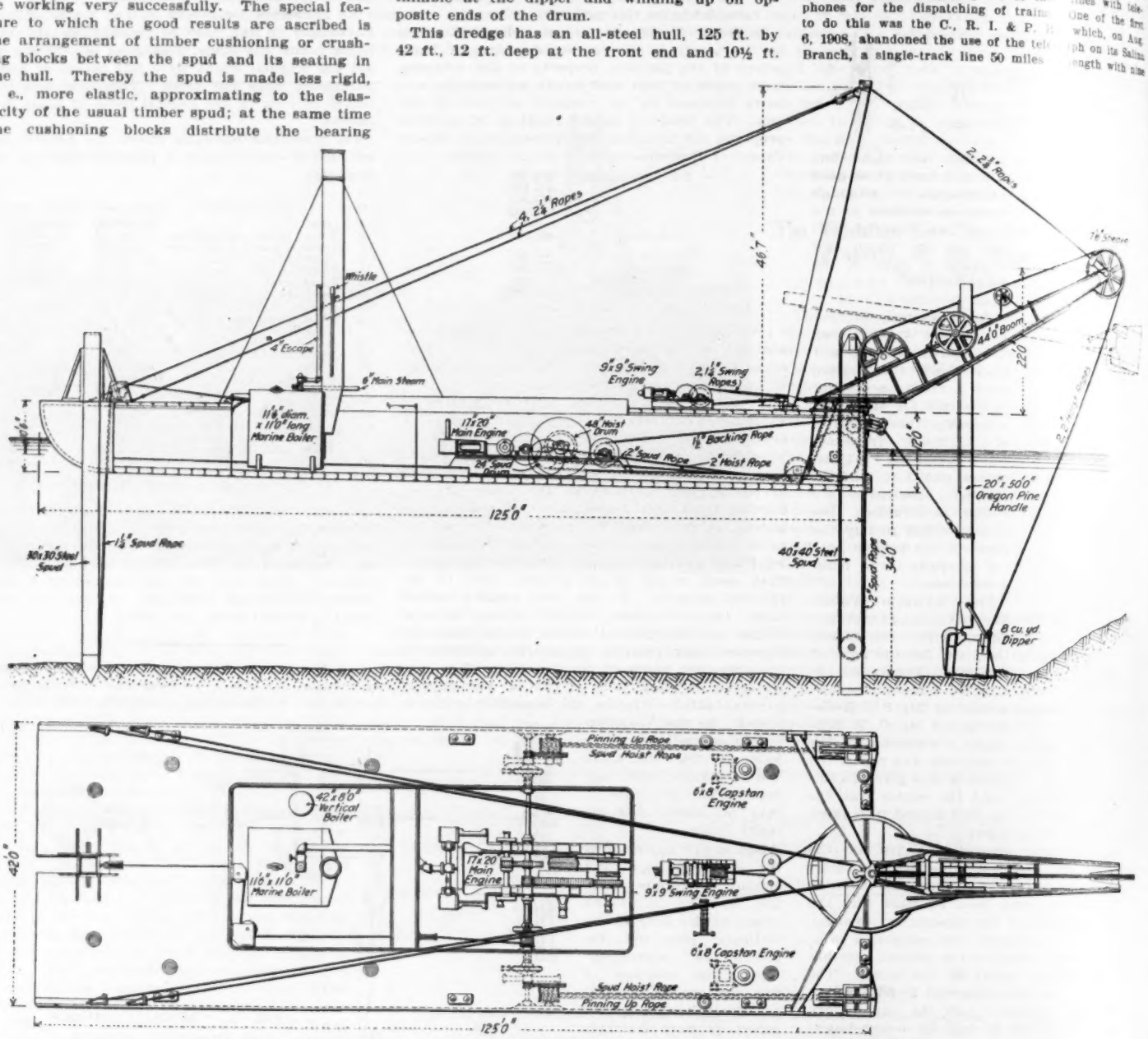


FIG. 1. DECK PLAN AND LONGITUDINAL SECTION OF THE "CAYO PIEDRA."

A RECORD FOR CONCRETE MIXING is reported from the Sacramento Hotel, recently built at Sacramento, Cal., where, on Sept. 3, 1908, 381 cu. yds. of concrete were made and placed in 8¾ hours. This involved the mixing of 315 cu. yds. of rock, 158 cu. yds. of sand, 572 bbls. of cement and 460 bbls. of water, and the hauling of the mix a maximum of 225 ft. and an average of 150 ft. The plant consisted of a No. 2 Ransome mixer, driven, by shaft connection, by a 30-HP. a. c. Westinghouse motor. Crushed rock and gravel were brought to the site by teams, dumped into large bins from which they were fed by belt conveyor to a charging hopper above the mixer. After mixing the concrete was dumped into a mechanical hoist and conveyed to its place on each floor by 10 men, each with a concrete cart.

Train Dispatching by Telephone on the Chicago, Rock Island and Pacific Ry.*

By F. W. FATHERS†

During the past year several of the leading Western railways have equipped parts of their lines with telephones for the dispatching of trains. One of the first to do this was the C., R. I. & P. Ry., which, on Aug. 6, 1908, abandoned the use of the telegraph on its Salina Branch, a single-track line 50 miles long with nine offices between Herington and Salina, Kansas and commenced to use the telephone for dispatching trains and transmitting messages. The next line to be equipped with dispatcher's telephones, was from Herington to Topeka, 16 offices with 80 miles of the busiest single track on the Rock Island. The telephone proved so satisfactory here that the management decided to install it on the most important division on the road. So on Nov. 16 the division between Blue Island and Rock Island, 165 miles of double track with 27 stations was equipped with dispatcher's telephones.

Previous to 1908, the telephone had been largely used in railway operation, principally at the larger terminals. For example on the Chicago Terminal division the company has had in use a telephone system between the La Salle St. station and the various freight houses, yard offices, interlocking towers, etc., for a long time. These telephones, however, were not used for dispatching trains though they were a great convenience in the transaction of routine work and made communication easy between the offices and many points otherwise inaccessible because of the expense of maintaining telegraph stations at outlying points.

The transition from the telegraph to the telephone for dispatching trains has not been accomplished, as one might imagine, by merely attaching ordinary telephone

*A paper read before the Iowa Engineering Society.
†Assistant engineer, C., R. I. & P. Ry., Davenport, Ia.

instruments to a telegraph wire. Instead, a complicated and expensive special equipment of wires and instruments has been installed which is used exclusively for the purpose of moving trains and the transaction of the routine of dispatching them.

As the writer is more familiar with the line between Rock Island and Blue Island, he will dwell more particularly on this division than upon the others.

The equipment consists, in the first place, of a circuit of two No. 9 copper wires stretched on the telegraph poles between the terminals. The dispatcher's office at Rock Island is the "Central" of the line and it is through his office that calls from one office to another are made. It might be said here that these calls are infrequent as visiting on the line is not permitted; the idea being that the line is for business purposes and under the absolute control of the dispatcher so that operators on the circuit with whom the dispatcher has dealings may be promptly called or may in turn call that official without delay.

The dispatcher is equipped with a receiver and transmitter similar to that of the ordinary Central, which leaves him with both hands free to manipulate train sheets, make entries in his order book, etc. But at this point the similarity between the dispatcher's office and the telephone Central ends. Instead of a switchboard the dispatcher has before him where they may be readily reached, a series of push buttons, one for each station on his circuit and a master selector clock with a starting button which controls a similar clock in each of the stations. These stations are furnished besides the clock with extension desk telephone transmitter, a receiver provided with a head clasp so the operator has both hands at liberty to make the tissue copies of his orders as transmitted to him and last, but not least, a gong for calling the operator.

The method of transmitting the order is the only difference between telephone and telegraph dispatching. The form is just the same (the Standard American Railway Association orders) and the orders delivered to the train men are copied in the same words on the thin tissue paper that is used in telegraph dispatching.

Let us follow the procedure of issuing a telephone train order. The dispatcher in his office has on the table before him his train sheet and order book. Deciding to deliver an order at Bureau, he pushes the button marked "Bureau" and then the starting button in his office, which sets in motion the master-selector clock and at the same time the clocks in all the offices on the circuit. Each clock makes a half revolution in thirty seconds and each station is given a number between 1 and 30 corresponding to its number on the master clock. Bureau, we will say, is 20—then when the clock has revolved 20 seconds and No. 20 reached, the gong at Bureau begins to ring. Its note is loud and insistent. The consequence is that the operator stops the noise as quickly as possible by pushing a button in his office, takes down the receiver and answers the dispatcher by his station name. The dispatcher is waiting for him and immediately gives him the type of order and number of impression copies to be made, as "31, copy five," and proceeds to deliver the order, at the same time writing it in the order book. The order is given in the following manner, all train numbers and other important parts of the order being first spelled out and then pronounced.

Order Number Ten.
Chief Dispatcher's Office, Rock Island.

C. & E. Number O-n-e, one; F-i-v-e, five, Bureau.
C. & E. Extra O-n-e, one S-e-v-e-n, seven F-o-u-r, four F-o-u-r four west, Bureau.
Number O-n-e, one; F-i-v-e, five, Engine O-n-e one F-i-v-e five O-n-e one T-w-o two will run T-h-i-r-t-y thirty m-i-n-u-t-e-s minutes late B-u-r-e-a-u Bureau to G-e-n-e-s-e-o Geneseo.

The operator writes this order as the words are pronounced, gives his X to the dispatcher when it is understood and repeats it to the dispatcher, who compares it with the original and checks it off word by word on his order book as it is received. When the order has been read to and signed by the conductors of the trains interested the dispatcher is notified, who at once makes it complete and gives the Chief Dispatcher's initials with the time. It is then signed by the operator and delivered to the conductors just like a telegraph order.

When the operator wishes to make an O. S. report to the dispatcher, he merely takes down the receiver, listens a moment and if the line is not busy, calls his station name and proceeds to deliver his message as "Bureau No. 7 out at 12.15"; the dispatcher acknowledges the receipt of the message and that closes the transaction.

The principal advantages of telephone dispatching are that it lightens the work of the dispatcher, who is generally an overworked official, brings him in closer touch with the operators, saves time in the delivery of orders principally because of the short time it takes to call the station operators—all of whom on the circuit may be called in thirty seconds if desired; opens up an opportunity for the employment of other than those familiar with telegraph for dispatchers and operators and because of its mechanical perfection is generally in working order. Frequently when the telegraph lines are out of commission on account of stormy weather, the telephone is working perfectly. Again when one operator fails to get another operator over the telegraph he asks the dispatcher to call the station he wants on the phone and generally it is only a few seconds until his reply comes though he may have been trying for half an hour to reach him by telegraph. Another point in its favor is that in case of an accident the dispatcher or superintendent can talk directly with the train men and get a much clearer idea of the situation than he otherwise could.

A few words as to the cost of the installation may be of interest. The line on our road was installed by company forces on telegraph poles belonging to the Western Union Telegraph Co. The original cost of the dispatcher's equipment was $165, and for each substation $55. Total for the line, Blue Island to Rock Island, 165 miles, $18,000.

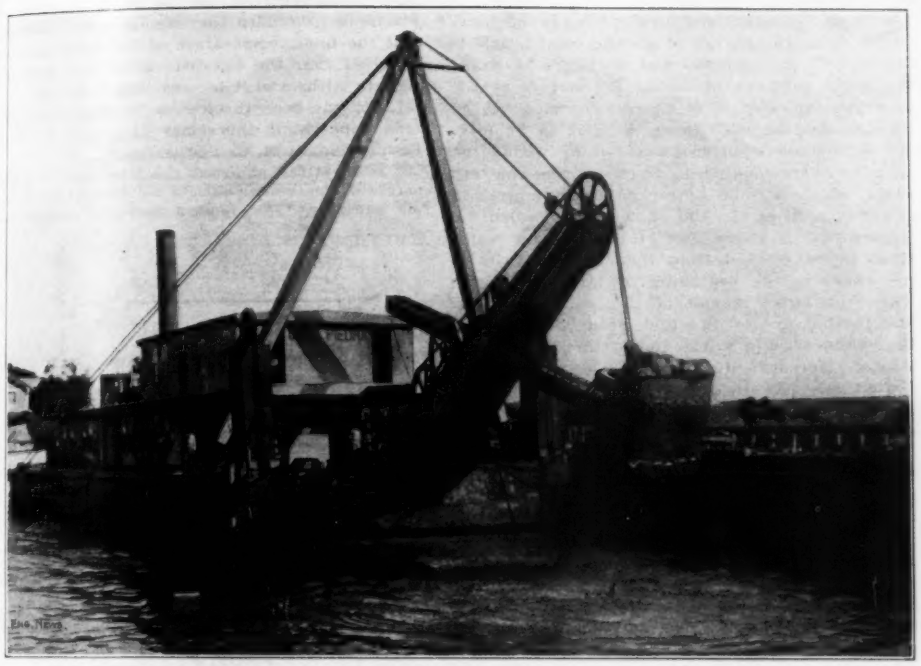


FIG. 2. THE "CAYO PIEDRA," 8-YD. DIPPER DREDGE OF DEPARTMENT OF PUBLIC WORKS OF CUBA.

(The spuds are riveted steel members, cushioned by belts of wooden blocks at top and bottom of hull.)

A BARGE-DUMPING MACHINE for delivering coal directly from canal barges to steamers or vessels has been built to facilitate the shipment of coal at Goole, England. The machinery is mounted on a pontoon or hull, which is moored alongside the vessel. The machine will take a small barge of 40 tons capacity, elevate it to the required height and tilt it so as to discharge its contents into chutes leading to the vessel's hold. The hoist is operated by hydraulic power. Machines of a similar character for handling and dumping coal cars have been built at many ports in this country and abroad, but are, of course, erected on piers or quays and have solid foundations. Many of the small canal barges used in England carry no more freight than an ordinary American freight car.

FIXING WATER RATES IN DENVER, in accordance with an ordinance passed by the city in 1907, is declared by the board of engineers which recently appraised the property of the Denver Union Water Co., to be quite beyond the powers of the Commission. The ordinance, according to the report of the Commission, provided

that the said rates shall be definitely fixed, and easily and plainly understood, and be fair, just and reasonable rates for the water supplied and services performed, and give to said company fair, just and reasonable returns upon a reasonable valuation of its property, and remain fair to both the company and the consumer during a period of twenty years.

The difficulty encountered by the arbitrators in establishing rates under the foregoing provisions was expressed by a letter addressed to the Mayor by Mr. M. L. Holman, M. Am. Soc. M. E., one of the arbitrators, as follows:

The difficulty which we encountered was, that a schedule of water rates which would give a fair return on the property at the beginning of the 20-year period, would in all probability bring in a return that would be unfair in from five to seven years and would inside of ten years bring about a repetition of the strife and contention that has occurred in the past. As the Board had no control (and very properly so) over the terms of the franchise they could not devise a flat rate schedule that would be fair for 20 years. In short, the ordinance imposed a duty on us which we could not perform and our only course was to decline an impossible task. This is the situation as I see it, and it is also the position which I took during the discussion of the rate problem.

The information given above was taken from "Denver Municipal Facts," a weekly journal issued by the city of Denver which is proving to be of great interest and value.

A SUDDEN RISE AND FALL IN A RIVER is reported by Mr. Francis W. Blackford, of the Montana Society of Engineers, in a paper before that society reprinted in the February, 1909, issue of the Journal of the Association of Engineering Societies. The Itentique "barranca," or tributary, to the Tuxpan River in western Mexico drains the east slope of two volcanoes, each rising some 14,000 ft. above sea level, and, on account of the steep slopes of its drainage area, is subjected to heavy and sudden floods. On Oct. 16, 1906, there was a rainfall of unusual severity even for this semi-tropical region and the Itentique soon began to rise, until by night the tributary was at its usual high water stage. The next morning the water level was the same as the night before but the evidences of damage and erosion showed that during the night the waters had risen about 60 ft. and had then subsided. Mr. Blackford describes the occurrence as follows:

The waters came down the "barranca" in tremendous volume, laden with earth, gravel, boulders, timber and other debris, quickly filling the little valley of approximately 80 acres in extent at its mouth and made a dam across the Tuxpan River about 60 ft. in height. This material extended up the river, more or less 1,000 ft. and down two or three times that distance, or to a point where the valley terminated in a narrow gorge. The waters of the Tuxpan River backed up behind the dam, which subsequently broke and water and debris went roaring down the canyon, doubtless in a manner similar to the Johnstown flood, carrying everything before it, and eroding the sides of the canyon and washing away the railway grade, even where it was in solid rock. The water backed up to the iron railway bridge about two miles above and piled driftwood against the spans, and when it subsided it carried the spans with it, depositing them in the bed of the stream several hundred feet below.

All of this occurred between dark and daylight of a very dark, rainy night, and nobody saw it. Those who camped on the hillside opposite the dam say they heard a great roaring in Itentique for about three hours. The next morning both the Tuxpan and the Itentique were at their usual high-water stage, but the topography of the neighborhood was materially changed. The Tuxpan had cut a channel through the dam, with vertical sides, about 60 ft. high. Itentique likewise had cut its channel about 60 ft. deep through the material it had brought down and piled up only a few hours before. With the exception of these two little canyons, the valley of about 80 acres remained filled to a depth of from 30 to 60 ft. I measured some of the granite boulders that had been brought down and estimated the largest at about 400 tons. The debris from this flood was in evidence in the canyon for a distance of 15 miles, as far as the railway line followed the river, and as far as my observations extended. The larger boulders were, of course, deposited first, the finer materials being carried further. I estimated the material deposited in the dam and in the little valley at about 10,000,000 cu. yds.; doubtless several million more were carried down the Tuxpan River.

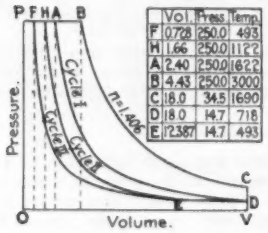
A Constant-Pressure Internal-Combustion Engine.

By H. B. STILZ.*

The idea of securing combustion, in a gas or oil engine, at constant pressure instead of constant volume during the period of combustion, is not new, for as early as 1873 Brayton, in Philadelphia, brought out his well-remembered engine in which gas and air were compressed in a separate cylinder and burned in the working cylinder. Brayton later gave up gas for petroleum vapor. In 1878 Messrs. Simon, of Nottingham, England, acquired the Brayton patents and brought out this type with a miniature steam boiler over the combustion cylinder. The steam generated was blown into the combustion area, but the engine was not especially successful. Hennig & Co., about this same time, in Germany brought out the Simon or Brayton engine with mechanical improvements. Foulis, of Glasgow, in 1878 patented an engine similar to the Simon, and in 1881 brought it out in improved form. In addition to separate compression and combustion at constant pressure, he utilized the exhaust gases for raising the temperatures of the incoming gases.

In theory all these engines proved very attractive propositions, but as mechanical difficulties multiplied for the small sizes of those earlier days, the simpler engine of the Otto type showed greater possibilities. Having compression, ignition and expansion in a single cylinder gave a simplicity with which the small constant-pressure combustion engines could not compete and they were abandoned.

They have been revived from time to time by various experimenters; but, in spite of the possibilities shown by theory, have proved up to the present of little importance—with the exception of the Diesel type. The writer believes that the causes of failure can be easily traced. Such actions have been pointed out in the following review of the theory of the constant-pressure combustion engine and serve as an introduction to the description of the engine designed by the writer and built under his direction.



	Vol.	Press.	Temp.
F	0.728	250.0	493
H	1.66	250.0	1122
A	2.40	250.0	1622
B	4.43	2500	3000
C	18.0	34.5	1690
D	18.0	14.7	718
E	12.387	14.7	493

Fig. 1. Constant Pressure Combustion Engine Cycles.

A Comparison of Gas-Engine Cycles.

If a volume of air is compressed to a higher pressure, a certain amount of work is performed upon it, and theoretically an equal amount of work can be obtained from it when this air expands to its lower pressure again. If, while the air was at the higher pressure its absolute temperature had been doubled (with increase of volume), then twice as much work is obtainable in the expansion as had been required in the compression, for obviously two volumes of compressed air will do twice as much work as one volume when expanding under like conditions. This increase in the energy of the expansion over the compression, was obtained from the heat energy absorbed in expanding, under constant pressure, to twice the volume with the rise of temperature.

A heat motor uses but a part of the heat energy within the fluid by which it is being operated. In the case cited, although theoretically twice as much work can be obtained in expanding as was required in compressing, still the amount of heat energy absorbed is considerably more than the equivalent energy which can be obtained from the engine, for the air leaving the expansion cylinder has approximately double the temperature of that entering the compressor cylinder and this heat is wasted, unless it can be used at some other stage in the transformation of heat into work.

In a steam engine, practically all of the latent heat of evaporation in the steam is lost in the exhaust, even in the most efficient engines being absorbed in a condenser. It is impractical here to use the heat contained in the exhaust since it is nearly all in the latent form, the steam being at so low a temperature that heat can be but slowly transmitted to any other body. This fact accounts in the greatest measure for the condition that in the most efficient steam engines, but little over a tenth of the energy available in the fuel can be converted into mechanical energy.

In a gas engine the amount of work delivered is the difference between the amount of work derived from the expansion stroke and that absorbed in the compression stroke. Therefore it would appear advisable to perform each of these operations in the most economical way. But a given mass of air is compressed with the least effort when kept at the lowest available temperature and obviously, as far as possible, all the heat resulting from the combustion should be retained within the gases during the expansion stroke and not allowed to be carried away in the water jacket.

With the standard engine operating in the four-stroke cycle, the charge of air and combustible is drawn into the cylinder and striking the walls, the inner surfaces of which are hot from the previous explosion, this charge becomes heated through contact with them, as well as by mixing with combustion gases remaining within the cylinder. The engine is thus compressing hot gases which become hotter as the compression proceeds until at the end of the stroke when the temperature is above that of the cylinder walls. Heat is transmitted from the cylinder walls to the gases at the beginning of the compression when the latter should be as cool as possible and in the reverse direction, from the gases to the cylinder walls at the end of the compression stroke. Moreover, during combustion, the highly heated gases are in direct contact with the relatively cool cylinder walls, which absorb a considerable portion of the heat produced in the combustion and this loss of energy continues throughout the whole expansion stroke. That a fluid operating in such unfavorable environments can deliver such a high degree of efficiency in the conversion of heat into work, can be accounted for only in consideration of the fact that dry air is one of the best known non-conductors of heat, and being to that extent independent of external conditions, performs its function according to inherent laws of its own.

In order to attain the ideal gas engine it would appear necessary that the working fluid should be compressed in cylinders adapted for keeping it cool during the operation and then transferred to cylinders designed to retain as far as possible within the gases all the heat produced in the combustion, where they may expand and do work. The efficiency of such an engine varies with the range of temperatures that can be successfully handled within the expansion cylinder. That engine will be most efficient which has the highest temperature at the end of the combustion and the lowest at the time the exhaust valve opens, the reduction in temperature taking place while the gases expand adiabatically from the high pressure just following combustion to the reduced pressure at the exhaust. The greater the difference between this maximum and this minimum pressure, the greater the range of temperature in the expansion stroke and therefore the greater the efficiency. The limiting high pressure which can be successfully handled is determined by the strength of the mechanisms comprising the engines. The limiting high temperature at the end of the combustion is such that, with the number of expansions available from the high pressure down to atmospheric pressure, the gases will leave the cylinder at a sufficiently low temperature not to injure the exhaust valves.

In the ordinary form of internal-combustion engine, it is customary to compress a charge of air and fuel to a moderately high degree and then to effect combustion at constant volume (explosion), thereby producing an extremely high working pressure. The gases are then allowed to expand adiabatically until the pressure in the working cylinder is lowered as much as practicable. The great difference between the original working pressure and the final pressure insures such a lowering in the temperature of the gases that a large amount of useful work is obtained while, at the same time, the exhaust valves are saved from being subjected to injurious temperature.

As pointed out, engines have been operated in such a manner that combustion is effected at constant pressure instead of at constant volume. However, in such cases where the compression is carried on in cylinders separate from those in which expansion takes place, the attempts have always been made with mechanisms which produce a pressure about equal to the initial pressure (before combustion) in explosion engines. Therefore the high working pressures found in explosion engines have never been obtained or even approached in the other form. Consequently, the expansion in these constant pressure engines having been from an initial pressure to a not much lower final pressure, the actual heat transformation in the gases has been so small as to render the engines very inefficient; and the final temperature of the gases has been so great that the exhaust valves have been unable to withstand it for any length of time.

Light has been thrown on the conflicting opinions concerning this class of engine by Prof. Bryan Donkin in his discussions.*

It seems at first as though this type ought, in accordance with the theories hitherto laid down, to give a very low efficiency, * * * because there is a constant temperature of combustion during the forward stroke, instead of an instantaneous temperature of explosion. The highest temperature attained is not very great and there is less range than in the other types. It is, however, an engine giving excellent results in theory and it is difficult to understand why these results are not realized in practice. The working defects are attributed chiefly to insufficient compression. The efficiency depends not on the highest temperature attained but upon the amount of compression and the greater the compression the greater the heat. In this class of engine, therefore, the usual rule is reversed and an efficient cycle is obtained with a low temperature of explosion. In the efficiency equation the ratio of specific heat does not appear because the burning gases are at uniform temperature throughout the stroke and the operations are effected at constant pressure.

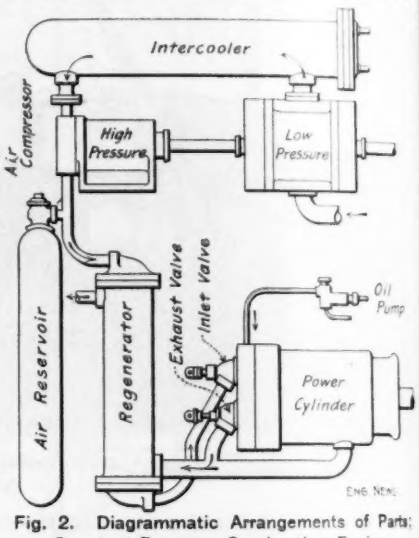


Fig. 2. Diagrammatic Arrangements of Parts; Constant-Pressure Combustion Engine.

$$\text{Efficiency} = \frac{\text{Heat developed} - \text{Heat exhausted}}{\text{Heat developed}} = \frac{C_p\,(T_1 - T_2) - C_p\,(T_3 - T_0)}{C_p\,(T_1 - T_2)} = 1 - \left(\frac{(T_2 - T_0)}{(T_1 - T_2)}\right)$$

(Where T_0 = initial temperature of gases admitted into cylinder,

T_0 = initial temperature,

T_1 = maximum temperature during combustion,

T_2 = temperature of gases at exhaust,

T_3 = temperature of compression,

cp = specific heat of gases at constant pressure.)

Taking data that has been secured with the

*1938 Marvine St., Philadelphia, Pa.

*"Gas, Oil and Air Engines," Second Edition, p. 240.

design to be described later, $T_0 = 493°$, $T_1 = 3{,}000°$, $T_2 = 1{,}415°$ and $T_3 = 1{,}122°$, we have, efficiency = 50%.

The results obtained from the Diesel engine have substantiated the theory. This is assuming that the Diesel motor in practice is nearer isopiestic combustion than isothermal, for which view some evidence is found. In the Diesel engine, however, the compression, combustion and expansion are all carried on within a single cylinder. Here the highest pressure obtained within the engine cylinder is produced in the compression stroke and by slowly injecting the combustible into the highly compressed mass of air, this maximum pressure is extended over a portion of the working stroke of the piston, the heat of combustion serving to cause the compressed air to expand at about the rate at which the piston advances in the cylinder. When combustion ceases, the gases expand adiabatically during the remainder of the stroke of the piston.

A comparison of such a Diesel cycle with a similar cycle in which the air is kept cool while being compressed, will indicate the advantage of having cylinders for compressing the air separate from those in which combustion and expansion take place. Such cooling, of course, must be done by multiple-stage compressors with intercoolers. There is a slight additional cooling by cylinder water jackets.

In Fig. 1 let cycle I., along the lines *A B C D A*, be performed in a four-stroke cycle constant pressure combustion cylinder, into which air is drawn from the atmosphere at 493° F., absolute (the temperature of freezing water). Suppose the hot walls, etc., of the cylinder heat this entering air to a temperature of 718° F., absolute, before compression starts. This compression along *D A* is accompanied by the transfer of heat from the cylinder walls to the air so that the curve is displaced from the position of an adiabatic. But the shape of the curve may be assumed as an adiabatic for ease in determining the area under it or the work of compression. Combustion at constant pressure occurs from *A* to *B*, adiabatic expansion from *B* to *C*, and from *C* to *D* there is exhaust to the atmosphere assisted by the separate stroke for clearing the cylinder for the next charge.

Cycle II., along the lines *H B C D E H*, is similar to cycle I., except that the operations are in a cylinder which does not transmit heat to the air before or during compression. Compression is begun then with air at 493° F., absolute, and, owing to the smaller volume (*O E*) of the given mass of air at this lower temperature, the compression starts at the point *E*, and continues along *E H* as true adiabatic compression.

Conceive cycle III., along the lines *F B C D E F*, to differ from cycle II. in having the incoming air compressed isothermally along *E F* at the entrance temperature 493° F., absolute. This necessitates an external compression cylinder, of course, a fact which needs no further consideration at this point. True isothermal compression is considered for this discussion. In practice it is only distantly approximated. The great gain practically as well as theoretically lies in avoiding the super-adiabatic compression of Cycle I.

The expansion curves of all cycles are common along *B C*. Therefore the same amount of work is done while expanding to atmospheric pressure in all three cases. This may be found from the area, Fig. 1, under *P F H A B C D V*, which consists of the rectangle under *P F H A B* plus the area under the adiabatic curve *B C*.

According to the well-known thermodynamic equation, which need not be derived here, the work of adiabatic expansion is,

$$P_b V_b + C_v (T_b - T_e) \quad \ldots\ldots (1)$$

where

P_b = pressure during combustion.
V_b = volume at end of combustion.
T_b = temperature at end of combustion.
T_e = temperature at end of expansion.
C_v = specific heat, constant volume = 131.4 for air.

The work in expanding along *B C* is, by this formula,

$$P_b V_b + 131.4 (T_b - T_e) =$$
$$159{,}500 + 172{,}100 = 331{,}600 \text{ ft. lbs.} \quad (2)$$

The work done in compression, cycle I., is then

$$P_a V_a + 131.4 (T_a - T_d) =$$
$$86{,}500 + 118{,}500 = 205{,}000 \text{ ft. lbs.} \quad (3)$$

For cycle II., the work of compression is:

$$P_h V_h + 131.4 (T_h - T_e) + P_d (V_d - V_e)$$
$$59{,}800 + 82{,}630 + 11{,}870 = 154{,}300 \text{ ft. lbs.} \quad (4)$$

The work of compression for cycle III. is found with the equation for an isothermal curve in place of the adiabatic before.

$$P_f V_f + P_f V_f \log_e \frac{V_e}{V_f} + P_d (V_d - V_e) =$$
$$26{,}250 + 74{,}400 + 11{,}870 = 112{,}520 \text{ ft.-lbs.} \quad \ldots\ldots (5)$$

The heat absorbed per lb. of air in any of these cycles during combustion period being:

[Specific Heat (constant pressure ft.-lbs) × Absolute Temperature Change.]

we have the following:

Cycle I; 184.77 × (3,000 − 1,622) = 254,500 ft.-lbs. ..... (6)

Cycle II; 184.77 × (3,000 − 1,122) = 347,000 ft.-lbs. ..... (7)

Cycle III; 184.77 × (3,000 − 493) = 463,200 ft.-lbs. ..... (8)

The thermodynamic efficiency then would be:

$$\frac{\text{Expansion work} - \text{Compression Work}}{\text{Heat absorbed, (ft. lbs.)}} \quad (9)$$

This works out as follows:

For cycle I,

$$\frac{331{,}600 - 205{,}000}{254{,}500} = 50\% \quad (10)$$

For cycle II,

$$\frac{331{,}600 - 154{,}300}{347{,}000} = 51.2\% \quad (11)$$

For cycle III,

$$\frac{331{,}600 - 112{,}520}{463.200} = 47.3\% \quad (12)$$

It will be seen that Cycle II. and Equation (11) apply to the discussion quoted from Prof. Bryan Donkin and check the computation made there.

No engine can operate without mechanical losses, and besides this heat is transmitted to the cylinder walls. Since the three cycles can be performed in the same sized cylinder, it may be assumed that the losses will be the same in all three cases. From a comparison of engines now on the market, the writer believes that the correct amounts may be stated as 44,000 ft.-lbs. in mechanical losses and 76,500 ft.-lbs. in heat transmitted to the cylinder walls, per pound of air used as the working fluid. The first figure is to be subtracted from the useful work shown on a diagram like Fig. 1, and the second must be added to the heat absorbed by the air or gas to give the total heat developed.

The actual efficiency of an engine working on cycle I, would then be

$$\frac{331{,}600 - 205{,}000 - 44{,}000}{254{,}500 + 76{,}500} = 25\% \quad (13)$$

For cycle II,

$$\frac{331{,}600 - 154{,}300 - 44{,}000}{347{,}000 + 76{,}500} = 31.5\% \quad (14)$$

For cycle III,

$$\frac{331{,}600 - 112{,}520 - 44{,}000}{463{,}200 + 76{,}500} = 32.1\% \quad (15)$$

The cooler the air is kept during compression, the more efficient will be the engine. The air should, therefore, at the end of the compression stroke, be at the temperature of the intake refrigerator, which condition necessitates sub-adiabatic compression. If this is carried out, then another improvement at once suggests itself; the expansion cylinder can be kept uniformly hot, by the fitting of heat retaining linings on such places within the cylinder as are not wearing

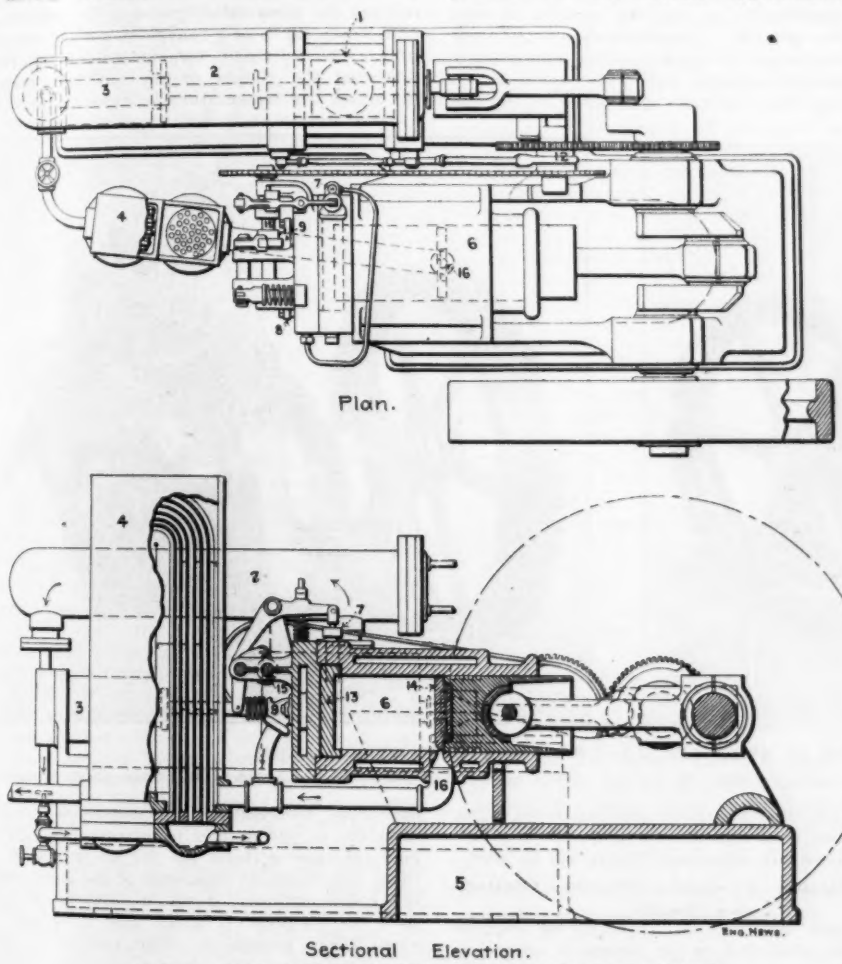


FIG. 3. PLAN AND ELEVATION OF CONSTANT-PRESSURE COMBUSTION ENGINE.
(Designed by H. B. Stilz.)

surfaces. This will greatly reduce the amount of heat transmitted to the water jackets and will also assist the ignition of the combustible. Furthermore, a regenerator can be placed between the compression cylinder and the expansion cylinder, with a most decided increase in efficiency.

At the end of the working stroke, the gases within the engine cylinder will have expanded to a pressure of 34.5 lbs. per sq. in. with a temperature of 1,690°. The exhaust port opens and the confined gases rush out into the atmosphere. There will be a resulting reduction in temperature, which is due to two causes; first, the gas will be given a high velocity, and the work producing this velocity must have been derived from the heat energy within the exhaust gas; and second, the gas will occupy a greater volume at 14.7 lbs. pressure than it did at 34.5 lbs. This increase in volume is effected against atmospheric pressure at 2,117 lbs. per sq. ft. The exhaust gas finally loses its velocity in meeting with resistances, and these resistances return to the gas all the heat which was absorbed in producing this velocity, but the energy expended in pushing aside a place for itself in the atmosphere causes a permanent reduction in temperature.

The exhaust gas can be considered as having expanded adiabatically to atmospheric pressure and as having its velocity destroyed before any transfer of heat takes place within the regenerator. Calling the volume of a pound of air at this stage V_x and since the volume before exhaust was 18 cu. ft., the external work done would be 2,117 $(V_x - 18)$. The temperature after exhaust being T_x (unknown) and before exhaust being 1,690°, the work done must have been equal to C_v $(1,690 - T_x)$, or $= 2,117$ $(V - 18)$. But from the familiar $P\ V = R\ T$, the volume of a pound of air at atmospheric pressure is $\frac{53\ T}{2117}$. Substituting this in the above equation

$$131.4\ (1,690 - T_x) = 2,117\left(\frac{53\ T_x}{2117} - 18\right);$$

and $T_x = 1,415°$.

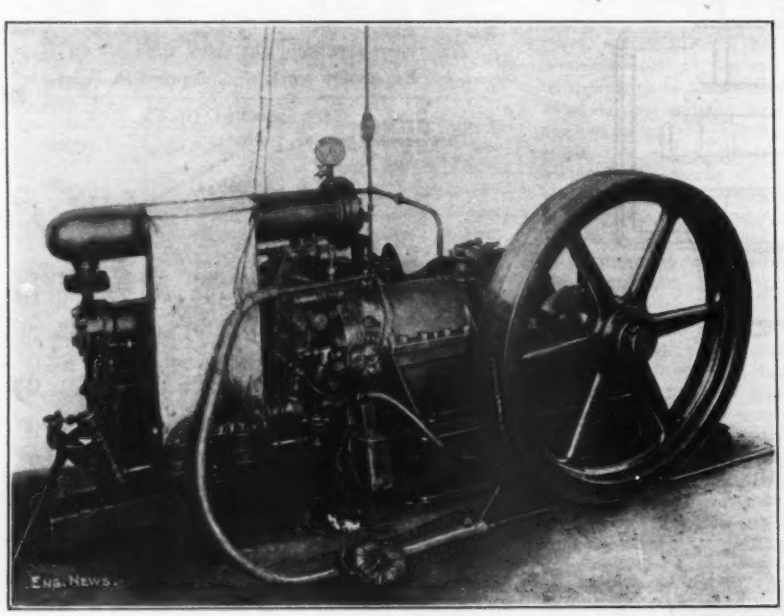
In theory compressed air would enter the regenerator at 493° F., absolute, and leave it at 1,415°, while the engine exhaust enters it at 1,415° and leaves at 493°. The heat energy which would be otherwise lost is then transmitted to the compressed air. The heat thus added may be pictured as replacing some of the heat needed to be developed during the combustion period. This, of course, raises the thermodynamic efficiency. Equation (12) becomes then

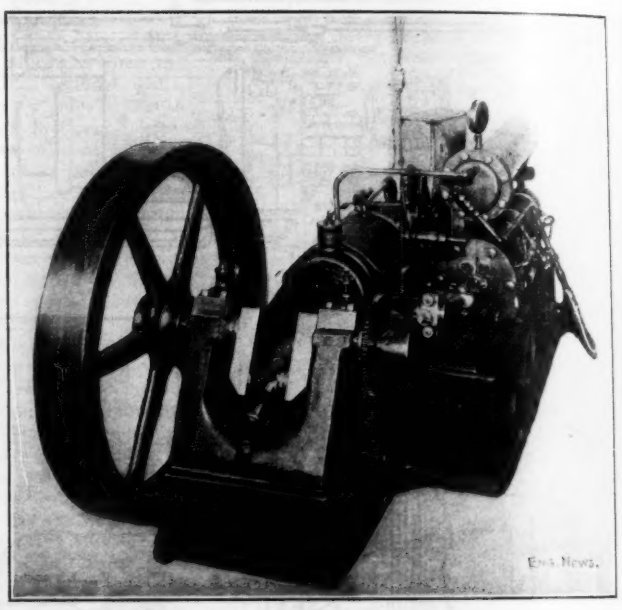
$$\frac{331,600 - 112.520}{184.77\ (3,000 - 1415)} = 74.5\% \qquad (16)$$

The writer's experiments show that it is reasonable to assume that the use of refractory linings in the expansion cylinder will balance the radiation losses in the regenerator, piping, etc. With the same mechanical losses the combined efficiency of an engine working on cycle III is shown by modifying Equation (15) to

$$\frac{331,600 - 112,520 - 44,000}{292,400 + 76,500} = 47.5\% \qquad (17)$$

This result is obtained with the comparatively low pressure of 250 lbs., absolute, and a maximum temperature of 3,000°F., absolute. Higher temperatures and pressures are handled successfully in practice and still higher efficiency can doubtless be obtained, perhaps over 50%. Isothermal compression must be approximated that the regenerator may be effective in transferring heat from the exhaust gases to the compressed air. With adiabatic compression the temperature of the compressed air would rise to about the exhaust temperature, so that no transfer of heat would be possible. Considerably more work would be required to compress super-adiabatically than near-isothermally and there would be no energy recovery from the exhaust. In the explosion and Diesel engines the expansion, after combustion, is in fact sub-adiabatic and less efficient than where refractory linings can be used.





FIGS. 4 AND 5. TWO VIEWS OF STILZ CONSTANT-PRESSURE COMBUSTION ENGINE.

(Power cylinder, 5½ × 7½ ins., single acting. Low-pressure compression cylinder, 4⅛ × 6 ins., double acting. High-pressure comp. cylinder, 2⅛ × 6 ins., single acting.)

A New Design of Constant-Pressure Combustion Engine.

The ideas discussed in the foregoing analysis have been embodied in the design of an engine which has been built and perfected to a certain point where the design seems, at present, more adapted to large units than to small ones. The writer believes that the former obstacles to a successful engine of this type have been recognized and overcome. Present difficulties are of details which remain to be worked out for the particular service in hand.

A diagram of a general arrangement to carry the working gases through the desired cycle is shown in Fig. 2. The engine as actually built is shown in Figs. 3, 4 and 5.

Air is drawn into the low pressure compressor cylinder (1) through passages in the bottom of the cylinder [controlled by valves mechanically operated from the eccentric (12)] and is delivered from the top passages into the intercooler (2), from which it enters the single-acting high-pressure cylinder (3) to be further compressed and delivered at about 500 lbs. per sq. in. pressure into the reservoir (5) located within the bed plate of the engine. The compressed air then passes through the 31 ⅜-in. copper tubes within the heater, around which the exhaust gases from the engine are made to pass. The heated compressed air is intermittently introduced into the power cylinder (6) through the admission valve (8) in a manner similar to methods used in steam engine practice. During the period that the air admission valve (8) is open the [illegible] pump (7) which is operated by a cam on the secondary shaft (15) is delivering oil into the cylinder in such a manner that the incoming charge of air carries it in a direction toward the igniter in an atomized state.

The oil burns on entering and causes the air to expand at constant pressure during a portion of the stroke of the piston. When the inlet valve (8) closes, the combustion gases further expand adiabatically until the end of the working stroke when the exhaust port (16) is uncovered by the piston and the spent gases are exhausted. The auxiliary exhaust valve (9) is simultaneously opened and is maintained open during a portion of the return stroke of the piston, closing in time to cause the remaining gases to be compressed to the pressure of admission when the piston reaches its inner dead center. The cylinder is then ready for a new charge of air and combustible. The adiabatic compression of the gases following the closing of the auxiliary exhaust (9) raises the temperature to about equal to the maximum temperature of combustion, so that after the engine is once in operation the process may continue without the aid of an igniter. If there was complete expansion of the gases within the power cylinder, down to atmospheric pressure, the temperature would drop from 3,000° to about 1,300° (absolute). That part of the gases remaining within the cylinder when the auxiliary exhaust closes, being then still at 1,300°, would be compressed to the pressure of admission with a rise in resulting temperature which, being between the same limits of pressure as was the expansion, would produce the same degree of rise as was produced in the previous drop. When the admission valve opened, therefore, the compressed gases would be at a temperature of 3,000°. When the exhaust opens before complete expansion is effected, the compression starts on gases at 1,415° (in the case cited), so that the temperature at the end thereof would theoretically be higher than 3,000°, say 3,300°.

Linings of cast iron (or preferably nickel) are placed on the cylinder head and end of the piston (13 and 14). These reach a temperature nearly a mean between that of combustion and that of exhaust (approximately a dull red) and not only assist in insulating the hot gases from the water-cooled cylinder walls but also in producing perfect combustion by preventing any

combustible oil from coming in contact with the cool surfaces.

In order to start the engine it is necessary that the oil be carried through a free passage by the air directly to the igniter, for if allowed to strike the cold cylinder walls or piston it is immediately condensed on these and does not reach the igniter.

A small pocket is cut in the linings (13 and 14) with the igniter located at the end thereof. The oil and air admitted to the cylinder are deflected directly toward the igniter. In order that the heavy oils may be burned, the igniter must possess sufficient heat capacity to immediately evaporate such parts of the oil as come into contact therewith and still maintain an igniting temperature. The igniter used consists of a plug through which a heavy alternating current is made to pass and is so constructed that the point of highest resistance is at the end within the cylinder. A heavy current is generated in the single turn of the secondary of the

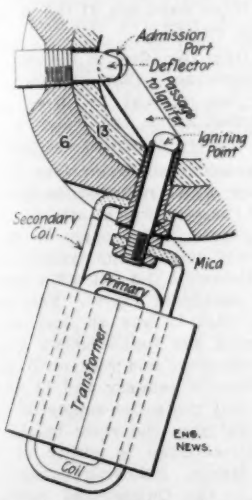


Fig. 6. Detail of Igniter; Stilz Engine.

transformer as a ratio of 112 to 1 turns is used. The igniter plug closes the secondary circuit. This plug must be of a nickel or like alloy which will not burn out.

By holding a charge of compressed air in the reservoir the engine can be started on crude oil in less than one minute after the igniter has been started, simply by opening the valve from the compressed-air system to the admission line.

The lever which operates the oil pump (7) is caused to raise the pump plunger by a spring, the cam driving it down. A stud passes through this lever and, by having a nut on it above the lever, the stroke of the pump and therefore of the quantity of the oil delivered can be controlled.

The system of controlling the admission and exhaust, of the working medium, into and out of the power cylinder is seen to be very much like superheated-steam practice so that this engine should be capable of development to possess all the points of flexibility of the steam engine. By a simple link motion the engine can be reversed or the operation of the valves can be changed by any other method found applicable. To many of the more practically minded engineers, the high economy of the design is of less importance probably than the possibility of starting under load, of reversing and of carrying overload. (The capacity of the compressed-air reservoir determines the degree and duration of the overload.)

Since the working pressures are limited only by the strength of the structures for carrying out the power cycle, since the engine operates on a two-stroke cycle and since each element is adapted for its one special operation alone, the weight, per unit of power developed, should be reduced to a minimum. These qualities, coupled with the fact that the cheapest grades of fuel oil are available, render the design described especially applicable to large units. This is important in marine practice where any space and weight reduction is important.

Sedimentation of the Water-Supply and Its Relation to Typhoid Fever in Washington, D. C.

By FRANCIS F. LONGLEY.*

The typhoid fever situation in Washington, D. C., since the beginning of the operation of the filtration plant in October, 1905, has been productive of a great deal of interesting and instructive discussion. Prior to that time the theory of water-borne typhoid had been quite generally accepted, to the utter disregard at times of other possible factors, which had all been grouped together and held responsible for the inevitable "residual" typhoid. Compared to other causative factors, polluted water had seemingly played a large part. Until the time mentioned, the high typhoid rate in Washington was supposedly due to the polluted condition of the Potomac water, until then unfiltered, which constituted the principal supply of the city. The conditions since that time have been discussed before the American Society of Civil Engineers, in the engineering papers, in the deliberations of the Medical Society of the District of Columbia, in the local press, and numerous other places. The fact that the typhoid death rate has not been materially improved, in spite of the admittedly thorough and efficient purification of the water-supply, has, after the most careful consideration of all phases of the question, led to the general conclusion that, while the danger of infection from the unfiltered Potomac water could not be denied, the part of this infection had played in producing the high death rate from typhoid fever in the District of Columbia had been comparatively small. That is the stand now taken by all who have given the question any consideration.

It has been hard to make any great progress beyond this point. It is true that the thorough investigations have shown the great need of a better milk-supply, as a substantial percentage of the typhoid deaths in the District of Columbia have been shown to be unquestionably traceable to infected milk. But there are still a large number of cases and deaths for which no clear cause is apparent—many more than would have been considered within the reasonable limit of the old accepted "residual" typhoid.

In the last two or three years a great deal of emphasis has been laid upon the need of a more thorough investigation of the causes producing this "residual" typhoid. One of the most noteworthy results of this has been a study of the typhoid conditions in Richmond, Va., by Drs. Levy and Freeman, of that city. The results of their study were presented at the last annual meeting of the American Public Health Association in Winnipeg, and the paper was reviewed in the Engineering News of Jan. 14, 1909 [Engineering Literature Supplement]. Certain remarkable facts brought out in this paper, which have a bearing equally upon the situations in Richmond and Washington, afford the excuse for presenting the following discussion.

The authors in the course of their studies plotted the curves of typhoid death rates for the two cities and were rewarded by finding a striking similarity in the curves. They follow each other very closely, and as the authors state, "long enough to eliminate the element of chance," and clearly enough to warrant with little doubt their conclusion that "there must be some little understood influences of a very widespread character, varying from year to year, which play a more important role in the epidemiology of typhoid fever than has as yet been recognized." In connection with this striking parallelism, the authors call attention to the water-supplies of the two cities. Briefly, the Richmond water-supply is taken from the James River; and during the entire 23-year period its condition has remained unchanged except for the natural increase of pollution due to the normally increasing population on the collecting area, and the gradual shortening of the period of storage due to the increasing rate of consumption in the city. The Washington water-supply is taken from the Potomac. At the beginning of the 23-year period the aqueduct system included two reservoirs. Since then another one has been added. (See Fig. 1.) During this period there have been times when one or another of these reservoirs has been out of service, and in some of the discussions on this subject that have taken place great stress has been laid upon the apparent relation between the variations in the typhoid death rate and in the period of storage resulting from the above changes in the reservoirs.

For a clear appreciation of this and to show the parallelism between the conditions in the two cities, Dr. Levy's diagram is here presented (Fig. 2). The notes relating to the Washington water-supply are taken from a diagram presented in the Engineering News of Nov. 8, 1906.

In the absence of the facts that have recently come to light, the consideration of the typhoid curve of Washington alone, for the period 1885 to 1905, together with the record of changes in the reservoir system, as shown in this diagram, led the ablest sanitarians to the seemingly logical inference that the increase in the period of sedimentation, at two different times, had so improved the quality of the water that a marked improvement in the typhoid conditions resulted. From the data then available, as the students of the Richmond situation point out, there seemed complete justification for such a conclusion. At the time of the discussions two years ago, only one inconsistency cropped up—namely, that the filtration of the water failed to have any effect at all comparable with that of a slight increase in period of sedimentation—but this was either ignored or explained away. This conclusion as to the marked sanitary advantage of the increased storage period is a most important one. If evidence were to be found tending to support it, it would be most welcome. Or if evidence appeared to disprove it, it certainly should not be withheld. As an incident of their studies, the authors of the Richmond paper question this conclusion. Since the discussions of two years ago, the writer has come across certain information that lends force to this objection.

In those discussions the information, upon which was based the conclusion as to the important part played by increases in the period of sedimentation, was quite general in its nature, consisting merely of *annual* typhoid death rates and the *years* certain reservoirs were in or out of service. Additional light is shed on this question if the figures are examined in more detail,

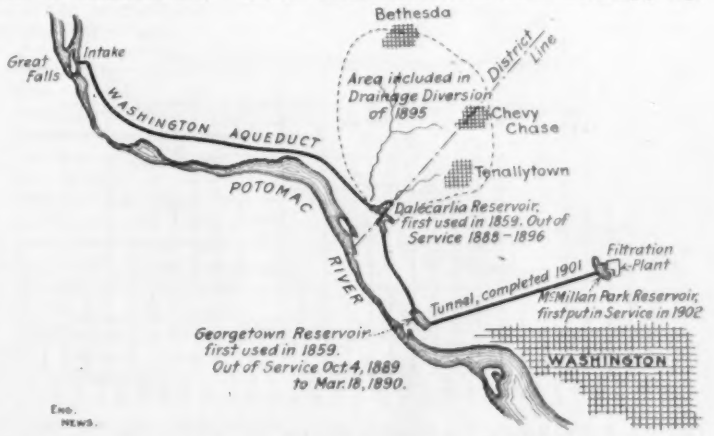


FIG. 1. GENERAL FEATURES OF THE AQUEDUCT AND RESERVOIR SYSTEM OF WASHINGTON, D. C.

*Chief Chemist and Assistant Superintendent Washington Filtration Plant, Washington, D. C.

the typhoid deaths by months and the data relating to the water-supply by days.

In considering a conclusion as important as this one, there would seem to be some value to be derived from an examination of the conditions that existed during a period when there was no storage nor sedimentation at all. Such a period occurred during the winter of 1889-1890.

The history of the water-supply from 1888 to 1896, as it relates to the period of storage and sedimentation (see Fig. 1), is as follows:

Previous to April 20, 1888, Potomac water flowing to the city through both Dalecarlia and Georgetown reservoirs, giving somewhat more than two days of storage and sedimentation.

From April 20, 1888, to Oct. 4, 1889, the Potomac water flowing to the city through Georgetown Reservoir only, giving about one day of sedimentation.

Oct. 4 to Nov. 12, Potomac water flowing direct to city without sedimentation in either of the reservoirs.

Nov. 12 to Nov. 15, entire supply consisted of the polluted water of Little Falls Branch, as will shortly be explained.

Nov. 15 to 30, supply consisted of a mixture of Potomac and Little Falls Branch water, with sedimentation of one day or slightly more in Dalecarlia Reservoir.

Nov. 30 to March 18, Potomac water again flowing direct to the city without sedimentation in either reservoir.

March 18, 1890, to Aug. 17, 1895, Potomac water again flowing to the city through Georgetown reservoir only, giving about one day of sedimentation.

After Aug. 17, 1895, Potomac water flowing through both reservoirs once more, giving a period of sedimentation of somewhat more than two days.

In order to understand the relation that these changes might bear to the quality of the water-supply, it is interesting to look into the reasons for the existence of these conditions.

Of those who have considered the matter, no

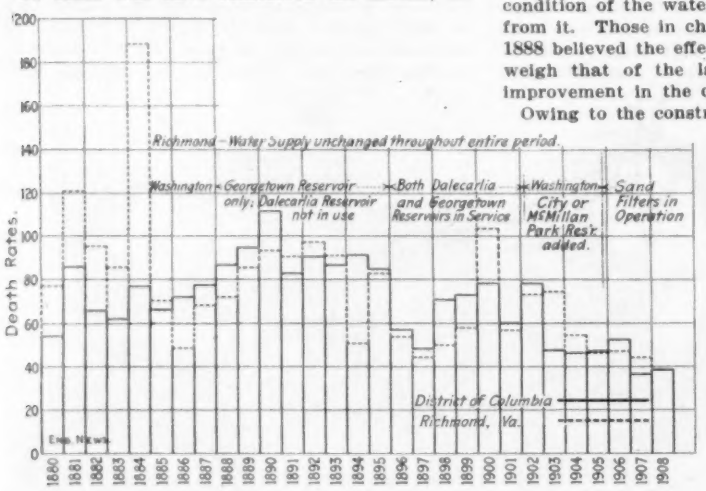


FIG. 2. TYPHOID FEVER DEATH RATES PER 100,000 FOR THE DISTRICT OF COLUMBIA AND FOR RICHMOND, VA., 1880 TO 1908.

(After Levy and Freeman. Typho-Malarial deaths are included. The diagram is designed to show the parallelism in the death rates of the two cities, notwithstanding marked differences in their public water-supplies.)

one seems to have inquired into the reason for Dalecarlia Reservoir being out of service from 1888 to 1896. These are the facts in the case, as shown by the permanent records of the Washington Aqueduct Office. From the time the reservoir was first built until the year 1895, it received, in addition to the Potomac water at Great Falls, the waters of the Little Falls Branch and other small streams having an aggregate drainage area of about 6 sq. mi., which included within its limits two suburban districts, namely, Chevy Chase and Tenallytown (see Fig. 1). It was the pollution carried into the reservoir by these streams that caused it to be put out of service, as the following will show.

In the report of the Chief Engineers for 1885, the officer in charge of the Washington Aqueduct presented a project for

intercepting streams and surface waters flowing into Dalecarlia Reservoir to secure the water-supply against pollution, and to allay the fears of the community in that respect.

This was repeated in subsequent reports. In the report of the Chief of Engineers for 1886, p. 2,022, there was contained the following:

During May and June of last summer (1885) there were very great complaints about the condition of the water supply, and the subject was very vigorously discussed in the newspapers. Many analyses were made. . . . which all tended to establish the fact that the water was not satisfactory.

Conditions became so bad that the officer in charge of the Washington Aqueduct finally took it upon himself to remove this pollution from the water-supply by cutting out the Dalecarlia Reservoir and supplying water direct from Great Falls to Georgetown Reservoir through the Dalecarlia by-conduit. This was done on April 20, 1888.

Recommendations were repeatedly made for the stream diversion required, and this was finally accomplished in 1895 and the reservoir put in effective service again on August 17 of that year with the polluted drainage of this 6 sq. mi. of suburban area entirely removed. It was thus out of service for a period of seven years and four months, with the exception of a short two-weeks period that will be referred to again. In the Report of the Chief of Engineers for 1896, p. 3,908, upon the completion of this work, there is the following:

These works of improvement were designed to divert from the reservoir the drainage from a water shed of about 3,825 acres, which drainage had so polluted its waters as to cause the reservoir to be thrown out of service in the spring of 1888.

The conditions that existed, therefore, just after April 20, 1888, were as follows: A considerable degree of pollution had been completly eliminated from the water-supply; the period of sedimentation of the Potomac water had been reduced approximately one-half. These two changes must have tended to produce diametrically opposite effects: the first to improve the condition of the water and the second to detract from it. Those in charge of the water-supply in 1888 believed the effect of the former would outweigh that of the latter change, giving a net improvement in the quality of the water-supply.

Owing to the construction of a new gate-house and 48-in. main connection, Georgetown Reservoir was put out of service from Oct. 4, 1889, to March 18, 1890, during which time, as stated above, the Potomac water flowed direct to the city without any sedimentation.

During the period 1888 to 1896, while Dalecarlia Reservoir was out of service, it became virtually a portion of the stream of the Little Falls Branch, and was filled with the polluted waters of that stream. In the course of the shorter period just mentioned when Georgetown Reservoir, too, was out of service, there occurred a freshet in the river, caused by a heavy rainfall of 3 to 4 ins. between Nov. 9 and 14, 1889. This produced the high turbidity in the Potomac invariably present at such times, and which in the absence of any sedimentation whatever went straight to the consumers. To save them from this undesirable dose of Potomac clay, and ignorant or heedless of the results to follow, the river supply was shut off and on Nov. 12 the comparatively clear but polluted water of Little Falls Branch stored in Dalecarlia Reservoir was turned into the mains. For a period of probably three days, then, until the Potomac water had again displaced the Little Falls Branch water in this reservoir, the entire supply for the city consisted of the polluted and undiluted water of this small stream.

On Nov. 30, the river had become normal again and Dalecarlia Reservoir was cut out as before, letting the supply flow direct from river to city. On March 18, construction work at Georgetown Reservoir was far enough advanced so that it was put in service again, giving the supply about one day of sedimentation. This condition lasted then until Aug. 17, 1895, when the works for the diversion from Dalecarlia Reservoir of the Little Falls Branch were completed and that reservoir put in service, practically doubling the period of sedimentation.

During the winter of 1889-1890, and having a direct bearing upon the question under discussion, there occurred in Cumberland, Md., a typhoid epidemic of no mean proportions. In a population of 12,000 there were 487 cases and 45 deaths. The first case occurred Dec. 10, 1889, and the epidemic flourished until about April, 1890. Cumberland is on the Potomac, about 150 miles above the Washington Aqueduct intake.

The typhoid fever conditions in the District of Columbia during the significant portions of this period are shown graphically by Fig. 3, which gives the actual number of deaths for each month of this period; and the maximum, minimum and average for corresponding months for about 22 years. The questions that naturally occur are:

(1) What deviation from the normal typhoid condition was there in Washington, during the Cumberland epidemic?

(2) What deviation from the normal was there due to the three days use of the polluted Little Falls Branch water?

(3) Aside from the effect of the two aggravated conditions mentioned, what other deviations were there from the normal in these five or six months, during which the water was supplied direct from the river without sedimentation?

During January, which included the 33d day, and February, which included the 81st day, after the onset of the case which infected the Cumberland water-supply, and brought on the epidemic, the numbers of deaths from typhoid fever in the District of Columbia did not differ from the normal to any significant degree. This was in spite of the fact that it was an open winter, with only 1 freezing day in December, 7 in January and 4 in February, and rain on 5 days in December, 9 days in January and 11 days in February; and that the water-supply of Washington came straight from the river to the consumer, without sedimentation in either of the reservoirs. In March, following presumably upon the height of the Cumberland epidemic, there were 19 deaths from typhoid in Washington, the highest number ever recorded for that month; and in April there were 11, which closely approached the maximum for that month.

The normal typhoid conditions in Washington in January and February, 1890, in view of these facts, seems surprising; while later the high death rates in March and April are what we would have expected, and seem explainable only by the infection of the supply from the epidemic at Cumberland. This suggests that the *degree* of the infection, of which in this case we have only an approximate measure, may be a factor of considerable weight in water-borne typhoid; or that a slight infection may, as has been suggested and proved by experiments in analogous cases, induce a hypersensitiveness in the individual to subsequent doses.

During December, 1889, which included the 19th to the 49th day after the polluted waters of the Little Falls Branch were turned into the city mains, there were 29 deaths from typhoid fever in the District of Columbia. This is far and away the highest point ever reached here in the winter months. As so frequently happens in cases like this, we have no proof that it was caused by the use of the Little Falls Branch water; but considering the known polluted condition of that stream, the fact that for several days it constituted the entire public supply, and in the absence of any other cause for the abnormal typhoid rate, it is a most logical inference that it was the source of the infection that caused so many typhoid deaths in December.

Assuming, for the sake of this discussion, that the high death rate in December, 1889, and March and April, 1890, were due to the specific infections noted, we still have three months—November, January and February—during which the numbers of typhoid deaths were below or but slightly above the normal; and during the periods preceding, in which infection in the water-supply might have had an influence upon the typhoid conditions, the Potomac water was supplied contin-

uously to the consumers in Washington without sedimentation.

Returning to the consideration of the diagram (Fig. 2) of Drs. Levy and Freeman: the removal of the considerable degree of pollution in the waters of Little Falls Branch without any marked diminution in the typhoid death rate; the reduction in the period of sedimentation without any marked increase in the typhoid death rate; and later, the entire absence of sedimentation for three months without any increase over the normal typhoid death rate; these facts, together with the almost perfect parallelism of the Washington and Richmond conditions at that time, as Drs. Levy and Freeman have shown, are food for thought in connection with that important conclusion of two years ago, that the increase in the period of storage from about one day to about two days had in 1896 caused a 30% reduction in the typhoid death rate in the District.

The diagram already referred to indicates that the third reservoir was added to the system early in 1902, and that not only the period of years following, but the next year, 1903, showed another 30% reduction in the mean typhoid death rate. From the information given in the diagram the casual reader would very properly infer that after January, 1902, the entire supply passed successively through Dalecarlia and Georgetown reservoirs and the new Washington City or McMillan Park Reservoir. If this had been so it would lend force to the conclusion that the reduction in the typhoid rate at that time was caused by the increased period of sedimentation. But this was not so.

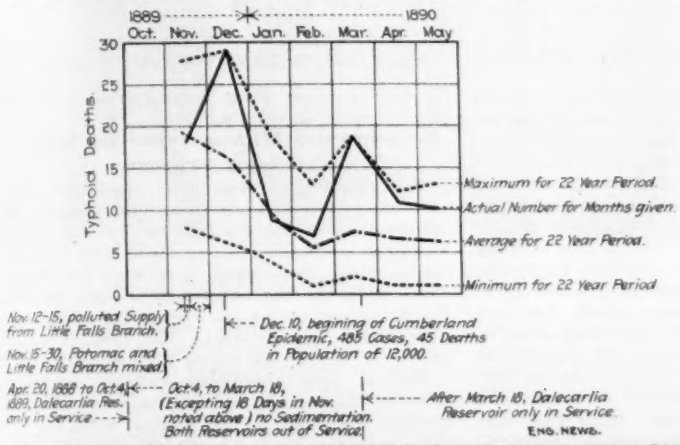

1889
1890
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May
30
25
20
15
10
5
0
Typhoid Deaths.
Maximum for 22 Year Period.
Actual Number for Months given.
Average for 22 Year Period.
Minimum for 22 Year Period
Nov. 12-15, polluted Supply from Little Falls Branch.
Nov. 15-30, Potomac and Little Falls Branch mixed.
Dec. 10, begining of Cumberland Epidemic, 485 Cases, 45 Deaths in Population of 12,000.
Apr. 20, 1868 to Oct. 4, 1889, Dalecarlia Res. only in Service.
Oct. 4, to March 18, (Excepting 18 Days in Nov. noted above) no Sedimentation. Both Reservoirs out of Service.
After March 18, Dalecarlia Reservoir only in Service.
ENG. NEWS.

FIG. 3. DEVIATION OF WASHINGTON TYPHOID CURVE FROM THE NORMAL DURING THE PERIOD OF NO SEDIMENTATION.

The records show that on Jan. 8, 1902, all connections between the tunnel, the reservoirs, and the city mains were opened and the new reservoir (McMillan Park Reservoir) put in service. No one has ever inquired into the adequacy of the distributing arrangements from the new reservoir, at that time, nor the actual quantity delivered to the city from that point. As a matter of fact, the facilities for the distribution of the full supply of water from this reservoir were not complete until long after this date, and part of the supply still continued to be drawn from Georgetown Reservoir. Means of determining the exact quantities supplied from the two reservoirs are not available, but the approximate proportions of the total have been worked up from the Aqueduct records of loss of head through the four-mile tunnel connecting these points. These determinations are as follows:

	Approximate percentage of total supply delivered to the city from	
	Georgetown Reservoir.	McMillan Pk. Reservoir.
1901....	100	0
1902....	74	26
1903....	64	36
1904....	52	48
1905....	43	57
1906....	0	100

The question that naturally arises is this, did the subjecting of only one-fourth or one-third of the total supply to an additional period of sedimentation and then sending it to the city to mix with the remaining three-fourths or two-thirds of the supply that had not received this further improvement, produce the great reduction in the typhoid rate that came at this time?

In October, 1905, the new filtration plant was put in service. It has been operated uninterruptedly since that date. The results of operation have been practically beyond criticism. The typhoid fever death rate, however, as has been pointed out many times, has responded but little to this improvement in the water-supply. The result of this has been, after the most careful study, the unquestioned conclusion that all were in some degree mistaken in blaming the Potomac water-supply in past years for the general prevalence of typhoid fever in the District of Columbia.

Now the Richmond investigators have brought forward evidence most striking and convincing in its nature, arriving at the same end, as far as the Washington problem is concerned, by an entirely different line of reasoning.

There is no question in the world as to the frequent relation between polluted water and typhoid fever. There seems to be no question as to their occasional relations in the past, in the specific case of the Washington water-supply. There is no question that in the general case with polluted water, the benefits of sedimentation increase with the length of storage period. And there seems to be no question that the Washington water-supply, aside from the highly important physical improvement, is materially improved in sanitary quality; and that the risks of water-borne infection during danger periods, before the introduction of filtration in 1905, were lessened by the storage here provided. But in view of the information here set forth relating to the two occasions where the period of storage and sedimentation was increased; the striking parallelism shown by the Richmond investigators, of typhoid conditions in that city and in Washington under widely different conditions of water-supply; the absence of the anticipated reduction in the typhoid rate after the introduction of filtration; the small part the water-supply has seemed to play in the general problem of typhoid in this city, which argument is itself made more forcible by reason of the preceding statements; all these seem to detract from the force of the conclusion of two years ago, that the increase in the period of storage as it occurred here in the two cases noted, caused the two 30% reductions in the typhoid death rate.

Because of the infinitude of factors, some clear and some obscure, entering into such a problem as this, specific deductions from each fact or set of facts are oftentimes unwarranted. Any one, no matter what his standing in the sanitary world, no matter how erudite his studies of the broad question of epidemic and endemic typhoid, who draws conclusions from data such as these, in which there is so often an "unbalanced middle," must expect at any time to have his conclusions questioned with further development of knowledge on the subject, or upon presentation of facts not previously brought to light. It would seem better in such involved cases simply to point out the salient points and leave it to each interested student to draw his own conclusions.

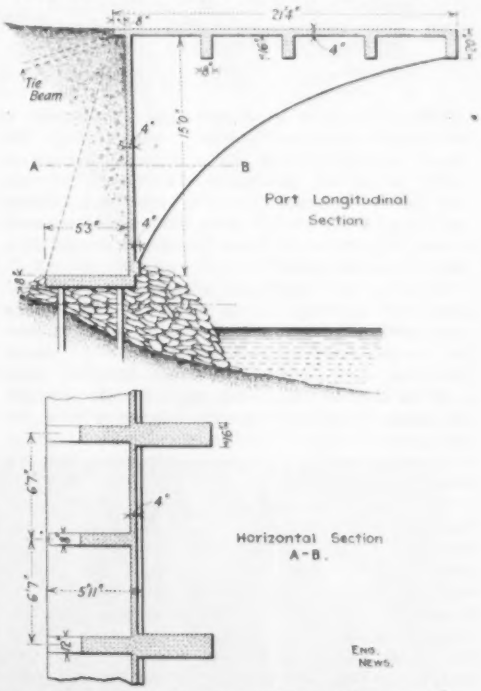
The writer has tried to avoid drawing conclusions from the isolated facts here set forth, because many of them may be interpreted in different ways; but he has not attempted to conceal his disbelief in any marked relation between the period of sedimentation and the typhoid fever death rate in Washington.

This discussion does not change the phase of the problem in this city. The authorities are still at sea, as are also those in Richmond and many other cities, in attempting to determine definitely the causes tending to produce the periodic recurrence of typhoid. More and more evidence has accumulated in the last few years, however, suggesting influences either hidden or unsuspected, and pointing out in addition to measures for eliminating water and milk infection; the importance of the utmost attention to the infinitude of details surrounding the *individual*, which may effectively protect him against the insidious attack of the disease favored by these unknown agencies. In this connection the interested reader is referred to the paper of Drs. Levy and Freeman, which is of unusual interest in this respect.

A Combination Retaining Wall and Quay.

The structure shown in the accompanying cut, part of the harbor system of Chantenay, near Nantes, France, is described rather meagerly, by M. G. Espitallier in a recent Bulletin of the Société des Ingenieurs Civils de France. The details of the construction are not given in the original publication, but there is enough to show the novelty of the design and its possible application to American practice.

The entire construction, except some ties hereinafter described, is of reinforced concrete. It consists of an L-shaped retaining wall with buttresses extending under the retained earth and cantilever corbels extending out over the adjoining sea; these corbels carry a floor system which forms the wharf or quay for the harbor. On account of the heavy overhang of the corbels the weight of earth on the base of the wall was not considered sufficient to preserve equilibrium, so tie-rods, of steel I-beams, were attached to the top of each buttress, as shown, and led back into dead-men in the retained earth. All of the members are dimensioned on the cut. We are unable to give the size or disposition of the reinforcing.



A Reinforced-Concrete Retaining Wall and Quay, near Nantes, France.

THE PATHFINDER DAM, under construction by the U. S. Reclamation Service as a part of the North Platte irrigation project, was 95% completed at the close of March, 1909, according to advance proofs of the Reclamation Record. The laying of masonry was resumed on March 3, and at the close of the month had reached a practically uniform height of 194 ft. above the foundation, or 20 ft. below the proposed roadway.

The Reconstruction in Reinforced Concrete of the Large Manufacturing Plant of J. B. King & Co., Staten Island, N. Y.

By ARTHUR G. HOADLEY.*

During the last six years J. B. King & Co., of Staten Island, N. Y., have had under construction a modern manufacturing plant, the history of which is of interest to the profession, not alone because of the engineering features involved, and the successful use of extraordinary methods in handling the work, but also because of the illustration it offers of the development in one distinct class of building construction. The plant, located on the north shore of Staten Island, Richmond Borough, New York City, has for its chief product wall plaster and cement, the daily capacity of these two items approximating 2,000 tons. Paint is also produced on a very extensive scale.

About seven years ago work was begun on a one-story building to be used as a cooperage shop. Since that time there have been 23 contracts completed on this same property. These buildings have been put to many different uses, such as sand storage bins, sand drying building, cooperage shop and storage, plaster mill, boiler and power houses, paint factory, finished goods warehouse, cracked gypsum warehouse and dry sand storage warehouse.

The map of the property, Fig. 1, clearly outlines the buildings, at the same time showing their position with relation to the water front and railroad, and the ideal shipping facilities enjoyed on both sides of the property. A spacious bulkhead extending the entire length of the plant permits the loading and unloading of the fleet of vessels and lighters maintained by the company. Hoisting and conveying machinery of several kinds are located along the bulkhead. The Staten Island Rapid Transit handles the goods shipped by rail and spurs, accommodating 16 cars run adjacent to the many buildings.

The first contract executed was for the erection of Building 7, a one-story building 60 × 100 ft., 14 ft. high at the building line, with the roof sloping up toward the center with a pitch of ¾-in. to the foot. The roof construction illustrates the reinforced-concrete design as practiced in 1902. Beams 1 ft. 5 ins. × 3 ins., spaced 3 ft. 3 ins. c. to c., reinforced with one ¾-in. square twisted bar, spanned between girders 15 ft. c. to c. The slab was 3-in. thick, reinforced with ¼-in. square twisted bars spaced 12 ins. c. to c. The square hooped columns 11 × 11 ins. were reinforced with four ⅜-in. square twisted bars and ¼-in. square twisted hoops spaced 2 ft. 6 ins. c. to c.

Buildings 7, 8 (A, B and C) and 6A were all built according to the design of Building 7. Building 6B was the first building to go higher than one story. Building 8C was torn down in 1906, and a five-story building was erected on the site. The interesting features developed in wrecking the one-story concrete section were published in Engineering News, Jan. 16, 1908, p. 75. The third floor of the new building was designed for 750 lbs. per sq. ft. and is to support a 78,000-lb. stone crusher.

Buildings 5A, B and C were erected in 1907. These were to be used for warehouses and packing purposes. Sections B and C were built as one building and ran 186 × 115 ft., five stories high, with a total floor area of 107,000 sq. ft. The upper floors were designed for 600 lbs. per sq. ft. live load. Owing to this building being erected on filled ground, where heavy piling was necessary, and also due to the proximity of the bulkhead to the building line, special precautions were taken to prevent local settlement under any one column, which might possibly result from the continual lapping of the waves. The first three footings under each row of columns back from the water side of the building were tied together with reinforced-concrete beams, 8 × 12-in. section, reinforced with two 1-in. sq. twisted bars. A steel trestle for cars which elevated sand from the unloading plant in building 6B at the ground level to the roof of 4C ran through the site of 5 B C, and the impossibility of removing it delayed the work considerably on the new building. Each floor was begun on the east end and continued until the trestle work interfered; in this way five floors were started and stopped, so that the appearance of the building from a distance resembled a series of steps. Blind windows cast of concrete and well reinforced were placed in the window openings left in the south wall of the building to allow that section of each floor to be used for storage bins.

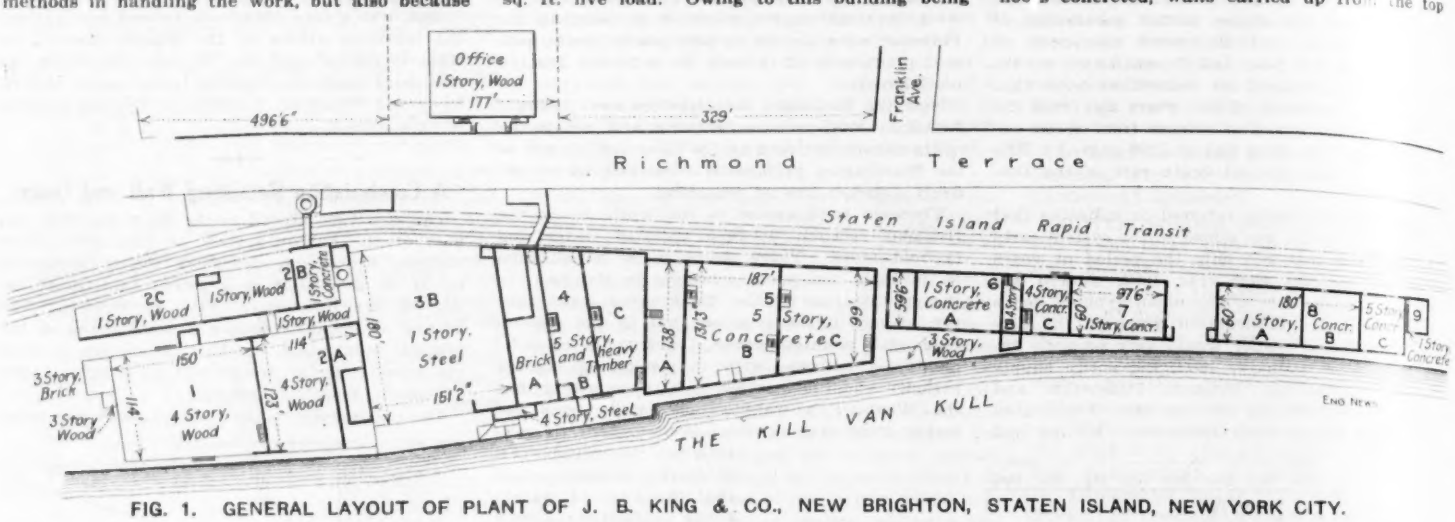


FIG. 1. GENERAL LAYOUT OF PLANT OF J. B. KING & CO., NEW BRIGHTON, STATEN ISLAND, NEW YORK CITY.

Fig. 2 shows the plant as it stands today extending from 5A to 8C, and also the beginning of the brick and concrete walls in the center of the third section of 5. Building 5A was originally of brick walls, with wooden floors and roof. The owner decided to make this fireproof along with the other two sections of this same structure; the wooden floors and roof were therefore wrecked and the new work started. This section runs 138 × 40 ft., and was formerly two stories high. Piles were driven, footings placed, floors concreted, walls carried up from the top of the old brick walls to the roof, and the roof completed in 45 working days.

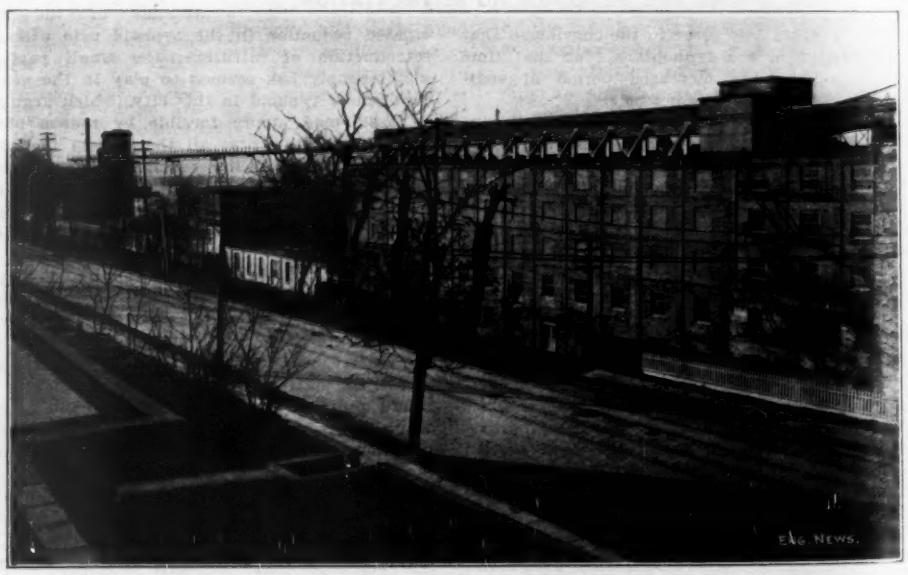


FIG. 2. VIEW OF THE J. B. KING & CO. PLANT LOOKING ACROSS STREET FROM OFFICE.

Reconstruction Without Disturbing Work in Existing Structure.

The buildings thus far mentioned were erected without encountering any serious difficulties. Either the site was bare or the original buildings were removed, so aside from the sand trestle before mentioned there were no obstructions to make the construction work unusual. Conditions governing the rest of the work, however, were quite different. The proposition was briefly to replace old frame or mill construction buildings with reinforced-concrete structures, without interrupting the operation of the machinery contained in the original buildings. It was impossible for the owners to discontinue the use of even one whole floor at a time, so the reconstruction work had to proceed by piecemeal. The manner in which the work was carried on presents some details which are believed to be novel, if not unique.

The conditions governing the reconstruction of Mill 2A building were severe and numerous. The building, as it stood, was a wooden struc-

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ture four stories high, running 113 ft. 8 ins. × 130 ft. 8 ins., enclosed by brick walls on the east and west sides and by wood partitions on the north and south. Story heights were 12 ft. 7 ins. in the first, 10 ft. in the second and third; the fourth story varied from 11 ft. 5 ins. to 16 ft. Two lines of shafting each carrying 500-HP. were driving numerous grinding mills and crushers; and were turning continually several thousand linear feet of screw conveyors. The building adjacent on the east side was dependent upon Mill 2 for part of its power; the coal-unloading machinery, which was attached to this building, had to work almost continually; engine and boiler rooms were on full time, consuming many tons of coal daily; great quantities of plaster dust had to be contended with; great precautions had to be taken against any accidents to the workmen; work had to be continued through the winter, and consequently ample precaution had to be procured for the manufactured product as well as for the new construction against the cold weather. These and many other conditions made it a contract which had to be handled from day to day, and no hope was entertained of being able to work to an advantage. A designing engineer was on the work continually, who, as far as possible, anticipated conditions far enough ahead to allow him to have the design submitted and approved by the contractor's engineering department. One of the most important conditions governing the success of this work was the cooperation between the representatives of the owner and contractor. The owner did all excavation, pile driving, shoring, looked after the placing of temporary supports for the shafting and machinery, removed all parts of the original wooden building after the concrete work was all in place, and removed all wooden posts where they interfered with the new columns. The contractor was to do all reinforced-concrete work, including the building and placing of forms, furnish new forms where necessary, otherwise to use the old wooden floor as a form for the new concrete slab. With the exception of a shutdown for a period of two weeks, caused by the breaking of an idler, during which time the contractor completed a very important section of the work, no time was lost by the owners due to the reconstruction of the building.

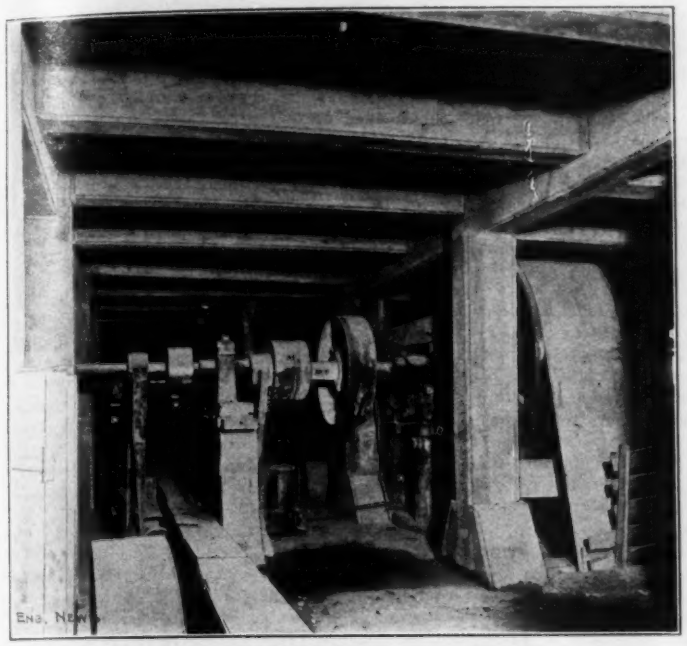

FIG. 3. SPREAD FOOTING UNDER MILL 2 A.

FOOTINGS.—The footings for this building were of a wide variety. The plan could only approximate the location of footings and columns on account of the impossibility of driving piles under the prevailing conditions with any degree of accuracy, as the site was made ground, consisting of old wooden cribbing filled in with large rock. In some cases an entire group of new piles were necessary; in other cases where the new and old column center coincided, extra piles were driven close to the original ones—which piles were found to be in an excellent condition after a period of 30 years in the ground. In still other instances footings were constructed on the top of brick foundation walls, which in turn were supported by piles. The problem of pile driving inside of the building was not a small consideration. In the majority of cases the two slides had to be separated and hoisted into the desired position, extending through holes in the second floor cut for the purpose, and there put together again. The hoisting engine was placed permanently in one position, and by the aid of numerous pulleys and long leads the hammer was successfully manipulated. Great difficulty was experienced at times in making the location of the footing and the position of its column in the upper stories work out without intersecting some shaft which could not be moved, or interfering with the location of new machinery which had been designed and ordered.

Twelve interior columns were carried only from the third floor to the roof, the support being a 24-in. brick wall which formed the enclosure for the boiler room in the original building. Fig. 3 shows the spread footing used in this case.

Plans which the owners had in mind for an addition to Mill 2 made it advisable to omit any footings or columns on the south elevation until a later date. Consequently girders, beams and floor slab which were designed to rest on the south wall columns for support were well shored and left ready to be connected to either the new addition or the south wall. The plan for the addition was abandoned and footings, columns and walls were run up, connecting with each floor in turn.

FLOORS.—The first and second floors were almost wholly taken up by the new and old engine room, boiler room and calcining kettles. The new work on the third floor was taken in sections, the first being over the boiler room, where 25-ft. clear spans were encountered. Beams 10 × 15-in. spaced from 5 ft. to 7 ft. 5 ins. c. to c. spanned from the 20-in. exterior brick wall to the girders supported by two lattice steel columns, which were used in these two cases on account of the lack of space immediately in front of the boilers for erecting the necessary form work for concrete columns.

Fig. 3 shows the large pulley wheel which came in this section and which was carried on temporary wooden supports made from the old floor joist, while the floor was being concreted. The breaking of the idler on the main driving belt made it possible to complete the reconstruction in this section while the mill was shut down.

The second section to be taken up was that over the old engine room where old 12-in. I-beams with brick arch construction were left in place and a cinder fill with a non-supporting concrete slab brought the floor up to the required level. The remainder of the third floor was constructed by using the old wooden floor as a form for the concrete slab. A section of flooring between two joists was cut and 1-in. dressed boards nailed crosswise to the bottom of the joist, which constituted a beam form. The flooring was cut on a 45° bevel at the beam sides to facilitate the work of removing the old flooring after the concrete was strong enough to be self-supporting. The girder forms were constructed in very much the same way. In some instances the joist ran parallel to the proposed girder line, and in this case two consecutive joists were separated a distance corresponding with the width of the girder and 1-in. dressed boards nailed to the bottom, as in the case of the beams. In the sections where the joist ran at right angles to the proposed girder line—after the proper shoring had been completed—a section 2 ins. wider than the proposed girder was cut through the flooring and joist from one support to the other and 1-in. dressed boards were nailed to the cut ends of the joist forming girder sides; then cross pieces were nailed to these on the bottom, as in the case of the beam form.

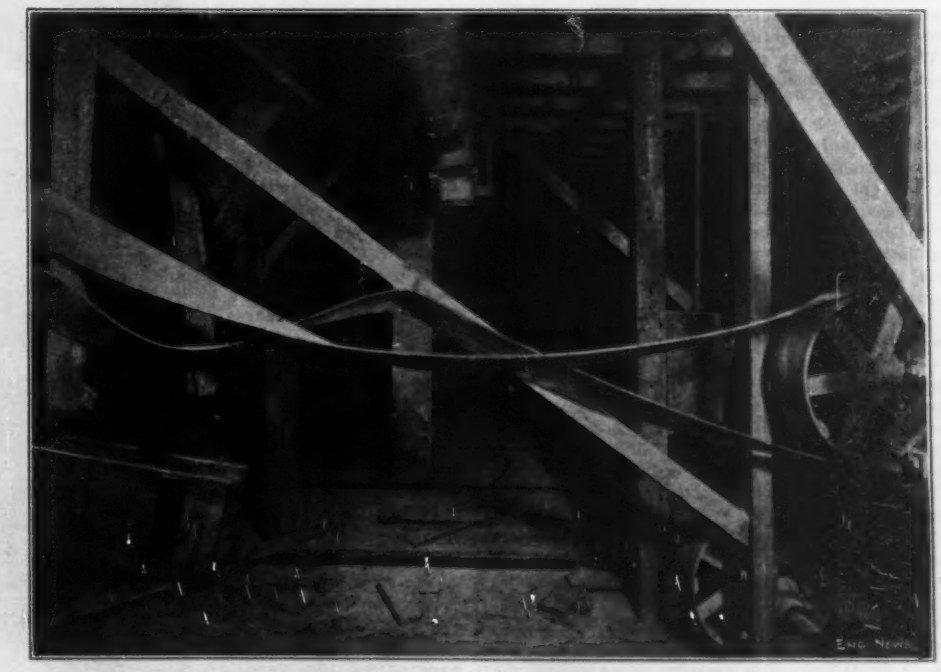

FIG. 4. FLOOR FORMS IN RECONSTRUCTION WORK.

Column forms in every case were built of new lumber. When the location of the old wooden posts and the new columns coincided, a hole

was cut through the floor above large enough to admit the new column form, the old post removed and shores placed to carry the load of the floor above. The greater part of the third floor was designed to carry a live load of 300 lbs. per sq. ft. The slab varied from 4¼ to 6½ ins. in thickness, according to load, and the reinforcement varied accordingly.

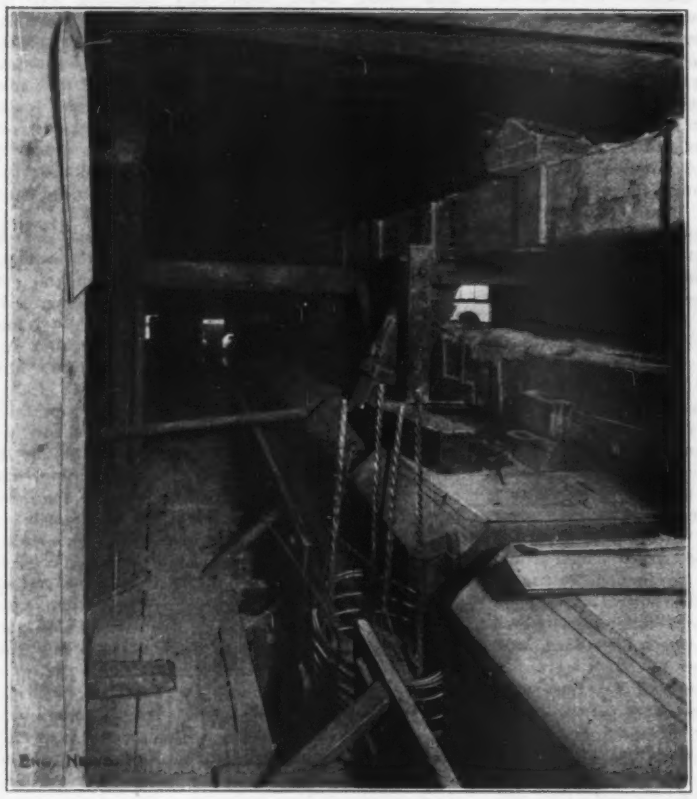

FIG. 5. FOURTH FLOOR, MILL 2 A, J. B. KING & CO.'S PLANT. RELATION BETWEEN OLD AND NEW FLOORS.

The very rapid accumulation of plaster dust on the surface of all exposed concrete made it possible to use the wooden floors as forms for the slab and have a surface which was sufficiently smooth for all practical purposes.

The fourth floor presented the greatest number of serious difficulties encountered in the entire building. Over 75% of the floor area was taken up with bins and conveyors, and many other mechanical devices necessary to the handling of the factory products, were either resting on the old floor, attached to the wooden posts or hung from the roof joist. This floor was also to be the most important one in the new building, because of the very heavy concrete storage bins which were to be located thereon. The original plan was to use the old floor as a form in this case, the same as was done on the third floor, but just at this time it was impossible for the owner to replace the third floor shaft hangers which had temporarily been hung from the fourth floor joist, on the new concrete floor. This condition resulted in the raising of the elevation of the new fourth floor high enough to allow new girder forms to rest on the old floor without cutting into the joist. New forms were therefore necessary for the entire floor. Dressed boards, 1 × 10-in. roof pine, were used for the panels, while 2-in. dressed spruce was used for the beams and girders. Fig. 4 illustrates the form construction for the concrete floor and also offers a fair example of the congested condition under which the contractor was forced to work. Fig. 5 illustrates the relation between the old floor and the forms for the new, also the column reinforcement. The following data will illustrate the irregularity of the beams and girders in this floor: Out of a total of 196 beams, 73 were of different dimension and span, varying from 4 × 10 ins. to 8 × 20 ins., and spanning distances ranging from 4 ft. to 26 ft. 9 ins. Out of a total of 69 girders there were 44 different, varying in dimensions from 10 × 12 ins. to 14 × 35 ins., and spanning distances from 5 ft. 7 ins. to 24 ft.

The floor was designed for a live load of 600 lbs. per sq. ft. over the open area and 800 lbs. over the portion to be covered by the storage bins. The cubical contents of this floor was 210,000 cu. ft., one-quarter of which was taken up with the storage bins. These bins were the full story high—16 ft.—and were anchored to both fourth and fifth floors by ½-in. square twisted steel bars 3 ft. long, bent at right angles at the center, one leg of which was securely fastened to the floor reinforcement, the other being fastened to the reinforcing steel in the bin walls. These bonds were placed every 24 ins. over space occupied by the bin walls. The excessive loads on this floor due to the storage bins, necessitated the use of a richer mixture of the concrete, as well as the additional reinforcing steel.

The construction of the fifth floor was much less irregular than the other floors. The original plan was to make a 14-ft. story height. This would have necessitated cutting into the roof along the central section where the gable was located, thus exposing belts, conveyors and machines to the weather. This was regarded as sufficient cause for raising this floor an additional 2 ft., thus making a 16-ft. story, and also allowing the old wooden roof to remain intact with the exception of holes cut for the columns, until the new floor was completed.

SHORING. — The removal of the old wooden supports necessitated exceedingly careful and well-planned shoring. Two shafts each carrying 500 HP. distributed power by means of belts and chains throughout the building, and the supports for these main shafts and numerous countershafts had to be removed from the old wood floor and hung from the ceiling during the reconstruction of each floor, then replaced in their permanent position.

This part of the work was very successfully handled by the owner's superintendent and his master mechanic. The only mishap being the breaking of one small countershaft, the coupling on which had been overlooked — consequently not properly tightened after the permanent supports had been put in place.

At one time during the reconstruction the two top stories of the old building were standing on the newly concreted third floor, which condition did not prevent the running of the machinery on the upper floors, nor did it interfere in any way with the use of these floors for manufacturing purposes. The shores consisted of the 8 × 8-in. posts, which were removed from their original position as the new work proceeded; 4 × 12-in. timbers and 6, 8 × 10-in. spruce piles which were on the property, being held for future work.

In starting each new floor the removal of the old supports was usually the first thing to be accomplished, and before this the necessary shoring had to be completed. The usual method was to hoist a piece of 8 × 8-in. timber to the under side of the joist on two sides and under the wooden girder on two sides, supporting these head pieces by 8 × 8-in. posts to the floor, tightly wedged. The old post was then removed and a hole cut through the floor above to receive the form for the new concrete column. No additional shores were necessary under the old floor to help support the dead load, but extra supports were placed under some of the heavy girders which extended below the bottom of the joist. Fig. 6 illustrates the shoring of beams, girders and slabs at the south wall line before footings and columns for their support had been run up.

PLANT.—The plant outfit for this work was composed of an electrically driven mixer and a continuous running single drum friction hoist which operated the automatic dumping concrete bucket. The plant was located in the passageway between buildings, 2A and 2B, the bucket hoist frame being erected directly against building 1 and about 10 ft. east of building 2. The mixer timbers rested on the ground and by using a charging hopper, the charging platform was elevated to a height of 7 ft. above the passageway, thus leaving an 8-ft. section adjacent to building 2B, free of obstructions for use by the owner in loading cars, handling the manufactured product, etc. At the level of the charging platform a doorway was cut through the

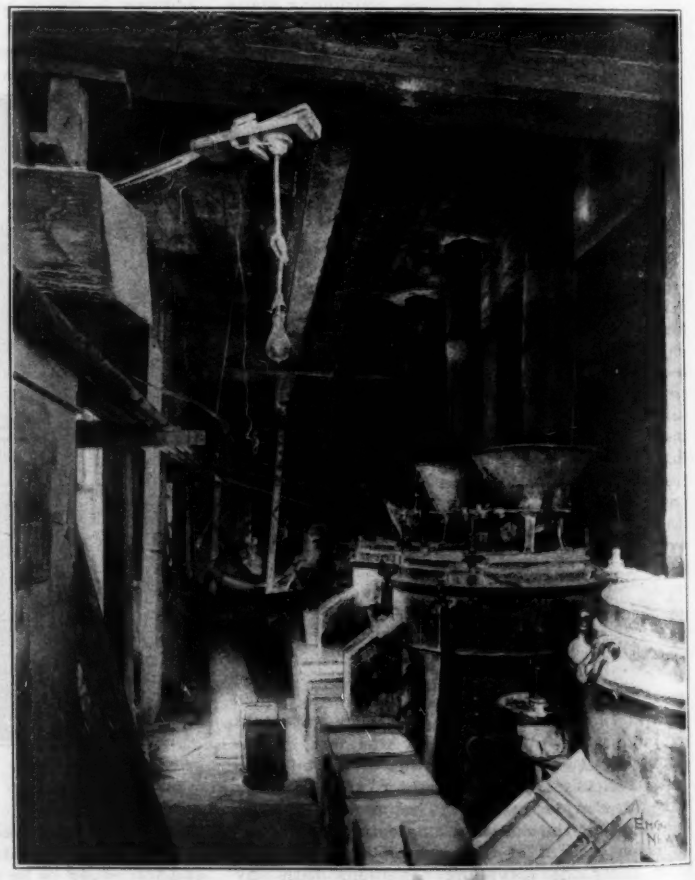

FIG. 6. SHORING FOR BEAMS AND SLABS JUST ERECTED.

brick wall of building 2B, making easy access to the material piles which were stored in this building. Sufficient space was allotted the contractor for the storage of 400 cu. yds. of gravel, 200 cu. yds. of sand and 250 bbls of cement, and was placed there under cover by the owner. The dry material was brought to the plant on scows and lighters and unloaded through building 1 by means of small hand cars.

The hoist frame ran sufficiently high to handle the concrete for the roof; dumping boxes being

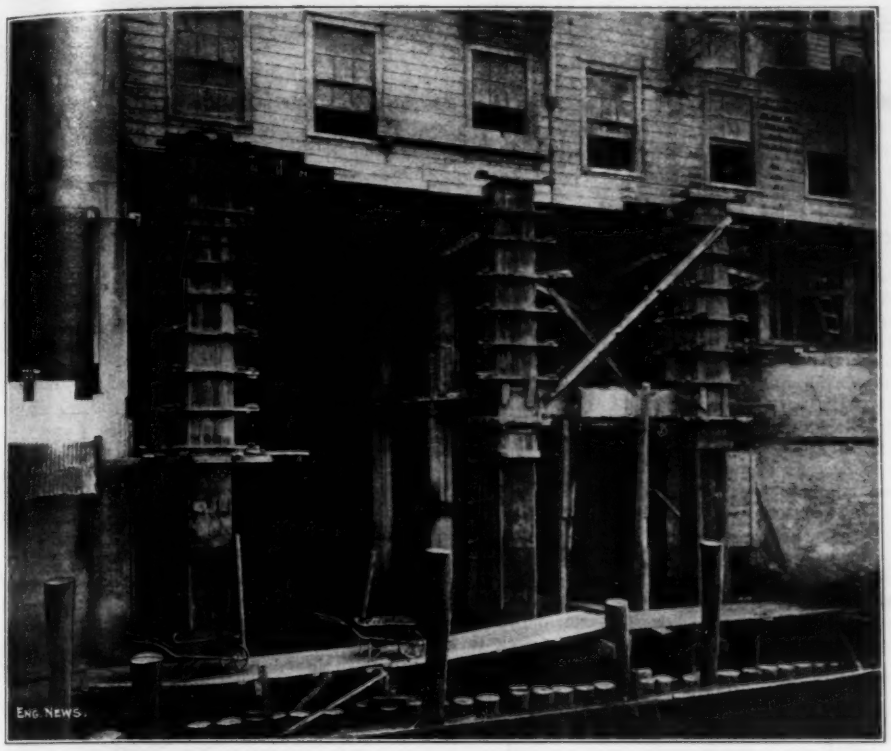

FIG. 7. A PORTION OF RECONSTRUCTION ALONG BULKHEAD, PLANT OF J. B. KING & CO., STATEN ISLAND, N. Y.

placed at the second, fifth and roof level. The third and fourth floor concrete was handled from the fifth floor level, which corresponded with the elevation of the old roof, and was delivered to these two floors by means of box chutes arranged with the view of delivering the concrete in a thoroughly mixed condition to the forms.

The specifications called for a 1:3:5 mix, with ¾-in. gravel, Cow Bay sand and a standard brand of Portland cement. The Ransome system of twisted steel reinforcement was used throughout the building.

Fig. 7 illustrates a section of this building along the bulkhead during the reconstruction, showing the method of building and placing pilaster forms, using 2 × 4-in. wooden bands and wedges; also the interior columns where bolts and 4 × 4-in. spruce braces were used. The concrete gang had just completed one of the girder wall ties and a laborer can be seen tamping same. Knee braces on the interior columns at the second floor line were left to receive the second floor beams, which were placed later.

This method of reconstruction causing such a small amount of delay and hindrance to the running of the machinery, etc., and the successful outcome of mill 2, have convinced the owners of the advisability of fireproofing mill 1, which is a mill construction building, in the same way. This work is to be started in the near future.

For all of the above work the engineers and contractors have been the Turner Construction Co., of New York.

LECTURES ON SAFETY DEVICES.—The executive committee of the Museum of Safety and Sanitation, located at 20 West 39th St., New York City, has detailed the Director, Dr. W. H. Tolman, for a tour of the country lecturing to chambers of commerce, manufacturers' associations, to engineers, insurancemen and architects' societies, to railway clubs, etc., on the work of the Museum in promoting the safety and welfare of industrial workers throughout the country.

A Skip for Cableways with Automatic Door for Dumping.

The common form of dumping skip in use on cableways of the Lidgerwood type consists of a rectangular, boiler-plate box about 7 × 7 × 2 ft. deep. It is open at the top and at one end and is dumped by elevating the opposite end by means of a fall rope controlled by the same engine that operates the hoisting cable. The open end, while necessary for dumping, restricts the capacity of the skip both by limiting the possible initial load and by promiscuously distributing a portion of this load during its passage to the dump, and workmen are occasionally injured by the falling stones.

An improved form of skip has been recently patented by Mr. Willard D. Lockwood, of Schenectady, N. Y., which, it is claimed, has doubled the capacity of cableways on which it has been used. The improvement consists in the addition of an automatic door to the open end of a skip of the common form. The door is closely fitted to the skip and is provided with wings at each end (Fig. 2) to further reduce the possibility of leakage. It is rigidly attached by steel bracing to the bail by which the skip is lifted, and, since the bail is held vertical during the dumping process by the weight of the skip, the door is left behind when the skip tips and automatically releases the load. This action is clearly shown in Fig. 2.

To prevent accidental dumping, the bail is attached not at the mid-point of the skip's length but at a point somewhat nearer the open end. This gives the skip a tendency to maintain the closed position and causes it to close automatically, due to the action of gravity, when the dumping chain is slacked. The tendency to ride with the open end elevated, due to the eccentric location of the bail, is neutralized by a chain which connects the bail staple to the closed end of the skip and supports a part of the load.

For convenience in loading by hand, when the skip rests on the ground the bail may be tipped back so as to lift the door up out of the way. When the skip is to be loaded by a steam shovel, the 45° braces from the door to the bail are replaced by chains so that the bail may be tipped toward the open end, leaving the top unobstructed and the door closed.

The dumping action is obtained not by lifting the rear of the skip but by slacking the main hoist while the dumping cable is held stationary. The standard Lidgerwood carriage is used, the sheave arrangement of which was explained and illustrated in Eng. News, July 25, 1895, p. 62. The tackle pulling the dump chain is made similar to that for the main hoist, and the hoist and dump cables are wound on drums of the same size. Thus, for straight hoisting or lowering, with the two drums turning together, there is no relative motion between the hoist and dump blocks and consequently no tendency to dump. When the skip is to be dumped, the dump cable is gripped and the main fall slacked, tilting the skip and at the same time opening the door. The dump chain may be made of such length as to give any desired degree of tip; the chain shown in the accompanying illustrations is somewhat longer than is commonly used.

For the information from which this article is prepared, we are indebted to the Cockburn, Barrow & Machine Co., 30 Church St., New York City, manufacturers of the skip described.

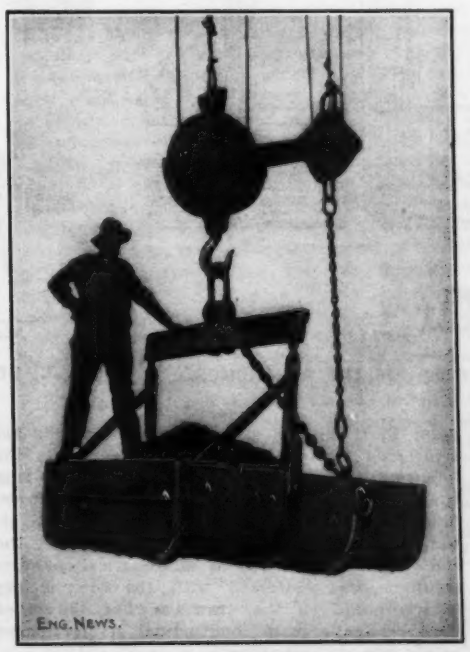

Fig. 1. Carrying Load; Door Closed.

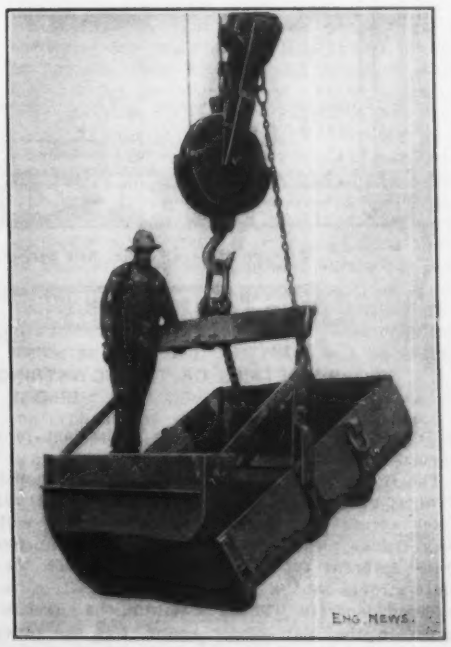

Fig. 2. Tipped for Dumping; Door Automatically Opens.

FIGS. 1 AND 2. AUTOMATIC DUMPING SKIP FOR CABLEWAYS.
(Willard D. Lockwood, Schenectady, N. Y., Inventor.)

The Application of Spiral Hooping to a French Concrete Bridge.

In this country the use of spiral reinforcement for concrete compression members has been comparatively limited and confined almost entirely to directly loaded columns such as ordinarily occur in buildings. In France, however, the development of the spiraled compression member has been most remarkable. Some time ago we showed a section through a reinforced-concrete beam made abroad in which the compression side was cared for by a hooping not connected to the longitudinal reinforcement of the tension side. In the present article we show a similar novel design in which the compression members of various types of bridges are formed by hooped columns, in some cases the hooping consisting of intercircling spirals, exceedingly complicated in shape and position. The description of the bridge is taken from a recent issue of the London "Engineer," and many of the details are lacking, but sufficient information is presented to convey a general idea of the type of structure. The design is by M. A. Considère, the well-known French authority on concrete, who devised the hooped column and who, of late, has devoted a large amount of his attention to its development. Some allowance must, therefore, be made for the design of an enthusiast in a special line of work.

FIG. 1. CONCRETE RAILWAY BRIDGE AT AVRANCHES, FRANCE.

The bridge, shown in Fig. 1, is at Avranches, France, and carries a meter gage single railway track across the river Sée and a series of railway tracks paralleling the river. It comprises three different types of structure, an arch, two plate-girders and a bowstring truss, all of reinforced concrete. There is nothing of novel interest in the plate-girder spans, but the other two are worthy of some attention.

In the bowstring truss (Fig. 2), the curved upper chord is of constant octagonal section, 1 ft. 7 ins. in short diameter, and reinforced with eight 13/16-in. and two 1⅜ in. longitudinal rods, spirally wound with 11/16-in. wire on about a 3-in. pitch. The lower or tension chord is of the section shown, 1 ft. 7 ins. × 1 ft. 9½ ins. and heavily reinforced with longitudinal ⅞-in. rods but not spirally wound. The vertical posts and diagonal braces are reinforced longitudinally only. The floor system consists of floor-beams spaced every 7 ft. 7¾ ins., carrying the most complicated reinforcement (Fig. 2)), and additionally braced by stringers underneath the rails and by solid floor slabs. A footway is made of a vertical and horizontal slab. Expansion is provided by the usual roller saddles under one end of the trusses.

The arch span over the river, with span of 110 ft. 2 ins. and a rise of 23 ft. 6 ins., has a solid no-hinged arch rib, 10 ft. 6 ins. wide and varying in thickness from 18 ins. at the spring to 14 ins. at the crown. The reinforcement of this rib consists of longitudinal steel bars wound around with intercircling spirals (Fig. 3) of ⅜-in. wire. The longitudinal rods are 1-in. in diameter near the outer edges of the rib but diminish to ⅝-in. in the middle. The member is further stiffened by the construction of three ribs, two at the outer edges and one in the middle, commencing at the spring where each is 1 ft. 4 ins. in depth and diminishing to zero at a point 15 ft. up the arch. These extra ribs are reinforced by ten 1⅜-in. rods stirruped to the longitudinal bars below. Upon this arch ring the solid 11½-in. roadway is carried by cross-braced columns, transverse floor-beams and longitudinal fascia stringers, from which latter, the sidewalks are cantilevered. The vertical spandrel columns are reinforced with the intercircling spirals noted on the drawings, but the other members have plain longitudinal reinforcement helped out with stirrups.

The bridge is designed for a load of two locomotives each weighing 23.1 tons (of 2,000 lbs.) on a wheel base of 7.2 ft., followed by cars weighing 15 tons. According to t[illegible] account in the "Engineer," the following str[illegible]s are computed for the various members [illegible] the bridge, taking into account stresses due to [illegible]ll live load, dead load, wind pressure and temp[illegible]ture.

	lbs. per sq. in.
Arch Ribs	740
Girders and Columns	555
Upper Chord of Bowstring	1,070
Steel	15,000

These appear to be quite high st[illegible]es under a moving and impact load, but the "Engineer" reports that a breaking test of a full size bridge of this type gave unit breaking stresses which would justify even the 1,070 lbs. per sq. in. noted above. This test bridge was designed after the type of the bowstring truss at Avranches. It was 66 ft. long, and consisted of two trusses of 7 ft. 7 ins. rise and spaced 8 ft. 2 ins. c. to c. The upper curved chord was heavily spiraled and was 10 ins. in diameter in all bays, but to ensure rupture at a certain place, the middle bay was reduced to 8 ins. This strut was reinforced longitudinally and spirally with 5.8% of metal.

The distance between columns in the trusses was not given. The concrete used was a 1:½:1 cement, sand, stone, mixture; considerably richer than in ordinary practice. The bridge weighed about 32 tons and was loaded with a quiescent load of rails until, under 270 tons, rupture occurred in the 8-in. middle bay of the upper chord. Under this load the computed stress in the 10 × 10-in. member, which was not broken, was 6,540 lbs. per sq. in. and in the 8 × 8-in. ruptured member, 10,240 lbs. per sq. in.

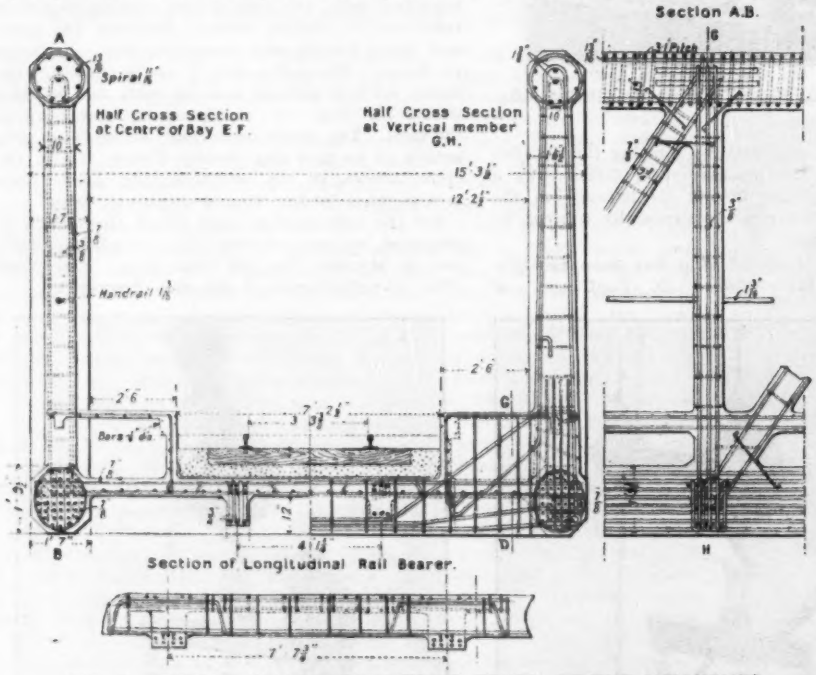
Section A.B.
Half Cross Section at Centre of Bay E F.
Half Cross Section at Vertical member G.H.
Handrail
Bars
Section of Longitudinal Rail Bearer.

FIG. 2. DETAILS OF THE BOWSTRING TRUSS OF THE AVRANCHES BRIDGE.

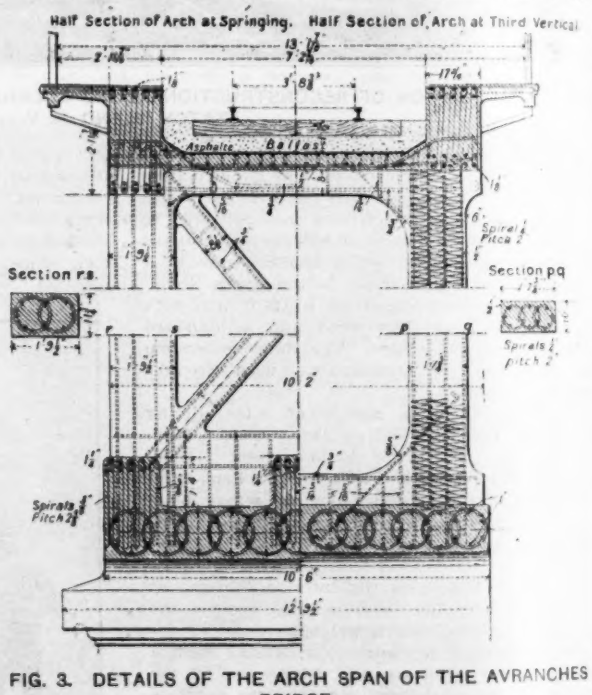

FIG. 3. DETAILS OF THE ARCH SPAN OF THE AVRANCHES BRIDGE.

A STEEL ARCH VIADUCT with a channel span of 300 ft. and approach arches of about 100-ft. span is projected at Cleveland, Ohio, to replace the Superior St. low-level bridge. The present bridge has a draw, while the new bridge, planned with a vertical clearance of about 90 ft., will not need a draw-span.

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The Pennsylvania State highway bill passed the legislature on April 15. According to the Philadelphia "North American," its final passage was secured by the personal influence and efforts of Jas. P. McNichol, a well-known contractor and politician of Philadelphia. As it goes to the Governor the bill appropriates $3,000,000 to be available during the next two years for the construction of a highway from Philadelphia to the Ohio line, going through Harrisburg and Pittsburg. The bill increases the salary of the Commissioner of Highways to $10,000 and of the Deputy Commissioner to $5,000. The Commissioner of Highways with the Governor and Attorney-General will supervise the construction of the road. The road is to be 45 to 60 ft. in width, but the width of the macadam is to be only 20 ft.

In contrast with this proposed $5,000,000 expenditure on a through highway in Pennsylvania it is of interest to place the action of Maryland, which is also to spend $5,000,000 on improvement of highways. The selection of the roads to be improved in Maryland has been left with a State Roads Commission. This body has made careful investigations and surveys and has selected the roads which are most used—and most useful—in each county of the state. Work upon these various roads is shortly to be undertaken.

There can hardly be two opinions as to which state will derive the greatest benefit from its $5,000,000 expenditure on road improvement.

In the beginning of the reinforced-concrete industry there was a very marked feeling against the laying of concrete in forms under vibration, such, for instance, as would be caused by machinery shafting in motion. The theory then held was that the constant minute movement of the enclosing forms tended to retard the setting of the concrete and to diminish its final strength. This theory seems reasonable enough, though so far as we know there have been no tests to prove or disprove it. Of late, however, the theoretical retardation in set and diminution in strength have not been regarded of sufficient importance by practical builders to cause the shutting down during the laying of concrete of machinery attached to forms. We have recently observed this disposition on the part of several large concrete contractors, but perhaps the most pronounced case is that noted in our present issue in the reconstruction of the entire plant of J. B. King & Co., on Staten Island, in a large part of which the processes of manufacture were continued throughout the depositing of concrete in forms intimately connected with moving machinery. This does not prove that the concrete is as strong as though vibration had not existed, but it does show that in necessary instances a reputable and experienced contractor feels assured of the safety of concrete subjected to this vibration, and the integrity of the finished work would seem certainly to justify his action at least in so far as the ultimate strength is concerned.

Incidentally, the work on the Staten Island plant exemplifies the remarkable flexibility of reinforced-concrete construction. Probably with no other structural material could the work of reconstruction have been carried on without shutting down the old factory for at least a part of the time. The complication of beam and girder layout, due to the peculiar placing of the various pieces of machinery, was such that the previous detailing necessary in steel-beam construction would have been tedious and difficult if at all possible, but in the adopted construction the forms for the horizontal members could be built to fit conditions and with the loose-bar system the reinforcement placed with a minimum of previous design and preparation.

The majority of public buildings suffer as regards their external architecture because they are so hemmed in by other buildings that they cannot be seen from a satisfactory viewpoint. Worse still, the buildings that hem them in are likely to be wholly unworthy surroundings for a public building, either in architecture or in the uses to which they are put. These facts have been rapidly gaining recognition in this country of late, and have led many public authorities and civic associations to secure or strive after larger open spaces and more dignified buildings around city halls, state capitols and various other local, state and federal buildings.

The movement just mentioned has taken two forms: (1) Provision of such ample open spaces, park or otherwise, around notable public buildings as either to make the character of the adjacent buildings of comparatively little moment or else to ensure that enhanced real estate values will lead sooner or later to a satisfactory class of buildings upon the surrounding property; (2) grouping a number of public buildings together, with the most important one of them in the center and the others about it, with as much open space as may be between the main and the subsidiary buildings. The second scheme will be recognized as the group or civic center plan.

At the present moment a notable example of each of the forms which this movement is taking is afforded: (1) As regards the state capitol at Harrisburg, Pa., and (2) as related to a new city hall, city auditorium and a clock tower of notable proportions between the two, at Springfield, Mass.

As to the proposed improvements at Harrisburg, it may be noted that the Pennsylvania Legislature has recently passed a bill providing $2,000,000, to be spent in equal sums during the next five years, for the purchase of a tract of land covering 19 acres and lying between the capitol and the tracks of the Pennsylvania R. R. According to the Philadelphia "Public Ledger,"

> This district is at present but poorly improved, being given over to dwelling-houses of a ramshackle order and the shabbiest appearance.
>
> . . . It is estimated that 75,000,000 railway passengers annually might see the building from the railroad if the vista were opened up by putting a boulevard and green lawn in place of the rookeries.
>
> The tract of land in question is very near the station, and the trains entering and leaving are at this point moving very slowly, so that there is an excellent opportunity to admire and appreciate the outward aspect of a building which at present cannot be seen from any vantage point sufficiently removed to do justice to whatever architectural distinction it possesses.

As to the Springfield project for municipal buildings and a clock tower, it has been endorsed by 70 of the heaviest taxpayers of Springfield, has already been approved by the Board of Aldermen by a vote of 7 to 1, and has passed one reading in the Common Council. From a recent public discussion and a reproduction of a wash drawing, both found in the Springfield "Republican" of April 17, it appears that the new buildings will be so located as to give open space at the front.

It is to be hoped that the proposed improvements of both Harrisburg and Springfield will be executed as speedily as possible. The reasons in favor of doing so, so far as we can judge from the information at hand, are so strong as scarcely to need detailing further than has been suggested above.

The recasting of ideas on the relations between water-supply and typhoid fever goes on apace. Not so very long ago it was generally considered that if a city had a high typhoid death rate its water-supply must be at fault. Accordingly, after the new slow-sand water-filtration plant at Washington had been in operation some months without any apparent consequent reduction of the high typhoid death rate which had been largely responsible for the installation of the plant, much disappointment was felt and not a little criticism to the effect that the plant was a failure resulted.*

The general conclusions of what we consider to have been the best informed discussion at the time was that other causes than the water-supply were responsible for the high typhoid mortality which had prevailed for years past at Washington. At the same time it was believed that the water-supply had had something to do with the high typhoid, and that this was proven by declines in the rate which had followed increases in the amount of sedimentation that the water had received before going to the consumers.

At the meeting of the American Public Health Association at Winnipeg in August, 1908, a notable parallel was drawn between water-supply and typhoid fever at Washington and at Richmond, Va., in a paper presented jointly by Dr. E. C. Levy, Health Officer of Richmond, and Dr. Allen W. Freeman, Assistant Health Commissioner of Virginia. These investigators showed that typhoid fever had followed the same general course at Richmond as at Washington, and that although, as had been reported, the water-supply of Washington had been improved at certain periods there had been no change in the Richmond supply—or at least only changes for the worse.

Elsewhere in this issue we present an interesting and important article by Mr. Francis F. Longley, Chief Chemist and Assistant Superintendent of the Washington filtration plant. It appears from Mr. Longley's article that information formerly current, and supposed to be official, regarding the provision of additional sedimentation for the Washington water-supply, was quite misleading in character. Not to go over the ground covered by Mr. Longley, it is sufficient to say here that through long periods of time when, as was supposed during the recent discussions, sedimentation was playing a very important part in improving the quality of the Washington water-supply, the water was really being so by-passed that there was no sedimentation.

We do not propose to consider this new light on typhoid and water-supply at Washington and elsewhere, further than to call attention to the additional emphasis which it lays upon the fact that public water-supplies no longer have to bear quite so heavy a burden of typhoid cases

*See Eng. News, Nov. 8, 1906, for special reports made for this journal by Mr. Theodore Horton, M. Am. Soc. C. E., Consulting Engineer of the New York State Department of Health, and Prof. William T. Sedgwick, of the Massachusetts Institute of Technology, and also for an abstract of a paper describing the filter plant, the paper having been written by Mr. Allen Hazen, M. Am. Soc. C. E., consulting engineer for the filters, and Mr. E. D. Hardy, M. Am. Soc. C. E., assistant engineer and later superintendent of the filters; also, see abstract of a report on investigations of water-supply and typhoid at Washington by the U. S. Public Health and Marine-Hospital Service in our issue of July 11, 1907. Editorial discussions appeared in each of these issues.

and deaths as formerly, and that much remains to be done by local, state and national health authorities in making clear what lines of work, other than those pertaining to the water and milk supplies, should be pursued in attempting to reduce typhoid fever in American cities to the level which it has shown for years past in a large number of cities of Europe. We bespeak in careful reading for Mr. Longley's interesting paper.

A Criticism of the Reinforced-Concrete Bridge Truss.

Until the designer of a new material fully understands its peculiarities, he must of necessity follow the standards proved efficient through long service of an older and somewhat similar material. Thus, at first, the details of iron construction imitated those in vogue for timber and similarly the first concrete constructions were but replicas of stone masonry. Later the introduction of steel into the concrete made it available for tension, and so reinforced concrete appropriated to itself many of the types and forms which had proved successful in steel construction; the usual reinforced-concrete building is precisely the same in general type as the knee-braced steel skeleton. It can be hardly expected that these copied forms can always be the best, but lacking any better precedent they must be used until time and experience develop better ones.

However, at times these imitations are so markedly defective that they should certainly be avoided. In this connection we desire to call attention to a tendency in reinforced-concrete design which seems to contain more elements of novelty than of efficiency. We refer to the increasing number of reinforced-concrete trusses and tower-bent viaducts, a few of which we have illustrated of late and most of which have so little to recommend them that their designers can hardly escape the charge of a bid for notoriety through the world-old craze for the "new thing."

In Europe, particularly in France, concrete trusses have been quite popular; in the present issue we illustrate one of considerable size recently completed at Avranches. In this country a few have been built. As a rule they take the form of a bowstring truss in which the upper chord approaches the form of an arch under compression, that is, for certain loads the entire stress is carried through this upper chord. The lower chord, under tension, is attached to the upper, sometimes by a diagonal and vertical system but more often, as in the Vierendeel beams, entirely by vertical posts. To these trusses the floor system is attached usually above the upper chord on posts, though sometimes the floor beams are attached directly to the posts as in the analogous steel type.

Laying aside the difficulties in erection in these concrete trusses, difficulties which are inherent in all small-form concrete work and which are gradually being overcome, and disregarding the ungainly appearance due possibly to unaccustomed form, there are at least two decided objections to such trusses of concrete, reinforced with loose bars depending for their connections merely upon their bond to the concrete. These are the indefinite distribution of the stresses and the possibility of deterioration through impact and vibration.

The transmission of stresses from one direction to another sets up secondary stresses at the joint, the exact nature and direction of which are quite indeterminate. In steel construction such stresses are resisted by riveted joints in which the rivets take the load either by direct tension or in shear and the amount on each rivet can be figured or at least closely approximated. In a truss in which the joint is made by reinforcement, more-or-less closely interconnected and covered with concrete, these stresses at joints are absolutely indeterminate and can not be figured against at all.

Furthermore, when the diagonal members are omitted from the truss system not only the secondary but the primary stresses in the members are impossible of exact computation. As an incidental but minor objection there are always certain members in such trusses that are acting purely in tension. Even the most prejudiced advocate of reinforced concrete cannot claim that the material is adopted for tensile stress alone. But in reinforced-concrete tension members the concrete is serving no other purpose than to protect the steel while at the same time it considerably increases the dead load.

As regards the possible evil effect of vibration on a concrete truss, it must be recognized that reinforced-concrete buildings are now standing apparently in perfect safety on whose skeleton the immense vibration of machinery is acting all the time. But there is considerable difference between constantly moving machinery and the suddenly applied pounding of a 150-ton locomotive and a train of 100-ton cars traveling at 40 or 50 miles an hour. This latter is what the reinforced-concrete bridge truss must stand and, granted even the best of workmanship in the manufacture and depositing of the concrete, we consider that it is a bold man who is willing to let the concrete-encased steel-rod joints of the concrete truss take this possible shock.

In any event, if such trusses are to be built, the reinforcement should certainly be of some connected type, in which the steel from each member effectively interlocks with the steel in each connecting member. Then the distribution of stresses at joints would be more assured than with the rod reinforcement depending for stress distribution upon its bond to the enclosing concrete. Foremost in such rigidly connected reinforcement are riveted structural shapes. With these not only is the stability of connections assured, but the ambition of the concrete designer to hang his forms to his reinforcement may be partially, at least, fulfilled. From this structural steel reinforcement to a steel structure enclosed in concrete is but a short step and if this latter can be made at all economical it would seem to offer a much better solution of the problem than any purely reinforced-concrete truss.

As we understand it, the main recommendation for the latter is its safety against deterioration and this is surely accomplished in the concrete-covered steel truss. We have published some few descriptions of this latter form over short spans—the only spans in which either of the forms is applicable—and we would recommend their study to bridge engineers who have meditated the construction of concrete trusses.

The concrete trestle or viaduct does not offer so fair a mark for criticism as the truss. As ordinarily built, these viaducts resemble in form the old type of timber trestle consisting of plumb or battered tower bents supporting girders. When the viaduct is low and the spans short there is no need of longitudinal bracing other than afforded by the girders themselves and the structure, aside from the possible damage due to excessive impact, is as safe and conservative in design as the skeleton frame reinforced-concrete building which it resembles in its detail. But when the towers are so high that they must be braced in the line of the viaduct the design runs into the freakish. An example of this is the well-known Richmond railway viaduct where in the long and high spans, reinforced-concrete girders 60 ft. long, 12 × 30 ins. in section and weighing 380 lbs. to the linear foot, are acting as longitudinal braces between two adjacent tower bents. It is the height of absurd design to have a member of such size to resist the small and indeterminate stresses from traction and wind, especially when it is stressed near to its own safety from its weight alone. In building such a viaduct the only way to avoid these long braces is to build the piers of box construction interbraced with diaphragms, an admirable form in reinforced concrete, or to shorten the spans, since the trussed braces often built in steel structures are impossible, or at least impracticable, in concrete. Here again the extreme bulkiness might be avoided by a structural steel reinforcement.

It will be understood that this criticism does not consider the possibility of poor workmanship in the construction of the concrete members, although in concrete trusses nd trestles both the difficulties of concrete de sitting and the necessity for a thoroughly w made material are at a maximum. But as ming that each member and each joint a thoroughly-mixed, completely-filled ger the comparatively slender, extremely avy concrete member is not adapted for the centrically applied and possibly reversed stresse of a bridge truss under moving load. And a ier whose dead load causes 75% of its to stress is uneconomical regardless of the amo t of that stress. It is not in a spirit of an gonism to reinforced concrete that this criticism is offered; it is merely a plea not to overwor a willing animal or to let an enthusiasm out gh sound engineering principles.

The Milwaukee Refuse Incinerating Plant Specifications and Contract Award.

For many years it was our unpleasant duty to call repeated attention to the unsatisfactory condition of refuse collection and disposal in American cities. Within the last two or three years marked reforms in these particulars have been made, or at least initiated, in a number of cities. The most recent and notable instance of a reform well begun was first noted in our issue of Jan. 16, 1908, when we published a report by Mr. Rudolph Hering, M. Am. Soc. C. E., on refuse collection and disposal at Milwaukee. Mr. Hering's studies and recommendations have recently borne fruit in the way first of specifications and second of contract award for a refuse incinerating plant, conceived on the best lines of recent refuse-disposal engineering. The specifications for the proposed Milwaukee plant are abstracted elsewhere in this issue, and following the abstract will be found a tabulation of the bids received. This tabulation includes some comparisons of the several bids on the basis of the interesting and novel guarantee clauses of the specifications. For details we refer to the article mentioned. In general, the scheme is to require certain guarantees as to the unit operating expenses and revenues (from steam generated) and to add the net cost to or deduct the net profit of operation from, as the case may be, 10% of the cost of constructing the plant.

Until quite recently the almost universal American practice has been to compare bids for garbage furnaces, as they have previously been called, on the lump-sum-cost basis, only. When the cost comparisons have gone further than this, the most that has generally been done has been to make some comparison of the cost of fuel per ton of refuse burned, and, later on, the cost of fuel and labor as well. The American contracts have heretofore seldom contained satisfactory provisions for contract tests of garbage or refuse furnaces. A few recent contracts, however, have shown marked improvements in all particulars designed to protect the cities involved.

Far ahead of us as the British municipalities have been in the matter of refuse furnace design, test and operation, they have not, so far as we have been able to learn, given any adequate consideration heretofore to all of the elements which should be taken into consideration in comparing the actual yearly or unit costs of burning refuse. Close attention appears to be given to the amount of steam or electric current generated by the heat given off in burning the refuse, and similar attention seems to be given in most cases to the fairly accurate determination of labor costs and sometimes the costs of repair. But even the labor costs in many instances seem to be restricted to those pertaining to charging, clinkering and cleaning the furnaces, leaving the various accessory costs of operation out of account and utterly disregarding the capital charges as a matter of unit cost.

Obviously, methods of comparison should vary with the objects of the comparison. It is perfectly proper to stop with comparing labor costs, if that is all that one for the moment needs to take into consideration. But in accepting or rejecting the bids for the installation of a refuse

incinerating plant, one should not stop with labor costs. Nor is it sufficient to add to a consideration of labor costs a comparison of the lump sums bid for installation. The real point is, what is the unit cost of disposing of refuse from the time it reaches the plant, by whatever means of transport, to the time of final disposition of the clinkers and ashes? A low cost for one element of the service may be offset by the high cost of some other element or elements.

In the Milwaukee specifications, an attempt has been made to take all cost items into consideration, in comparing the different bids. Inasmuch as general plans were prepared by engineers, certain features of installation were common to the plants proposed by all of the bidders, and therefore could be eliminated from the unit-cost comparison, although they should of course be taken into account by any one who wishes to forecast the total cost to the city of refuse disposal by burning, as compared with disposal by reduction, or by dumping.

Scarcely less remarkable than the plan for comparing bids and the means provided for testing the incinerating plant at Milwaukee are the bids themselves. There were four bidders, each of whom saw a way of getting considerable revenue from burning the refuse. The successful bidder guarantees not only a revenue, but one in excess of operating expenses and capital charges combined—or about 8 cts. per ton, net. This, however, makes no allowance for capital charges on the chimney and on the superstructure of the building, but neither does it take into account hoped-for revenue from the clinker residue, which it is expected can be put to some useful purposes.

The results of the tests of the plant will be awaited with interest. The crucial test will be that of service under American municipal conditions. We hope the city authorities of Milwaukee will see the need of adopting business and engineering methods in operation as well as in construction.

It is a particular pleasure to call attention to the latest attempt of Milwaukee to handle its refuse-disposal problem, in view of the city's many previous and unsatisfactory attempts to deal with the same matter. These were outlined briefly in the abstract of Mr. Hering's report which we published in our issue of Jan. 16, 1908, and were recounted at considerable length in an article which we published on Jan. 23, 1902. Milwaukee has not been alone in having shown heretofore gross municipal incompetency in refuse disposal. Most of the larger cities of the country that have thus far made any attempt whatever to get away from the most primitive and unsatisfactory methods of disposal have made equally as many blunders as has Milwaukee. We congratulate that city on having broken away from its extremely unsatisfactory past habits, and we express the hope that other cities which have not yet begun like reforms will speedily follow the example of Milwaukee and the few other progressive cities of the country.

A Revival of the Constant-Pressure Internal-Combustion Engine.

When the internal-combustion engine was first recognized as capable of development into a commercial machine, the now common type of explosion engine was not regarded as the type most likely to succeed. Instead, a type was favored in which the combustible was burned at a constant pressure with a corresponding increase in volume, the combustion period closely resembling the admission period of the reciprocating steam engine.

The appearance of the simple Otto engine before the ideas of Brayton, the pioneer inventor in the "constant pressure" field, were well commercialized, was unfortunate for the latter. The possibility of more immediate service from the Otto design, the limitations of the Brayton engine in small-sized units (for large engines were unknown in those days), the limitations of that day in mechanical engineering and in machine construction—all these things contributed to the development of the Otto engine and to the relegation of the Brayton engine to the list of unpracticable inventions.

It has never been forgotten, however, that in theory the Brayton type offered possibilities of greater thermodynamic efficiency. Nearly every writer on thermodynamics and heat engines has lamented those limitations, or distractions, of our machine designers and builders which have prevented the production of a commercial constant-pressure internal-combustion engine.

There has been, in recent years, a notable revival of interest in the older principles so that the engine designed by Mr. Stilz and discussed in another part of this issue is worthy of study by engine designers generally.

When constant-pressure combustion engines are mentioned, the Diesel oil motor immediately comes to mind so that it seems worth while here to note the differences between it and the engine designed by Mr. Stilz. In the very first place it is well to remember that the Diesel engine is intended to work with a constant-temperature combustion period rather than a constant-pressure. An amount of air sufficient to burn the maximum engine charge is compressed on one stroke so that the adiabatic rise of temperature is above the ignition point of the fuel oil, sprayed in after compression. Injection of this fuel is designed to maintain the compression temperature until the point of cut-off is reached. This would be accompanied by a decrease of pressure and an increase of volume. Adiabatic expansion follows cut-off. With this approach to a Carnot cycle there is conceded to be a lower mean effective pressure than when a cycle is employed in which the addition of heat is at a constant pressure of the gases and a given weight of gas in the working cylinder carries less energy. On the score of its theoretical cycle, then, the Brayton engine, and Mr. Stilz's modification, can be considered a higher type than the Diesel. It is doubtful, however if the Diesel motor, in practice, operates as nearly to isothermal combustion as to isopiestic. Mr. Stilz has assumed this in the article mentioned before.

The Diesel motor adiabatically compresses air already heated and gives it an added temperature rise. This work converted into sensible heat is not lost, however, and may be recovered as work during the adiabatic expansion. There is still the full waste of heat by the exhaust gases. In the Stilz design, the compression, being more or less isothermally that of cool air, is accomplished with less work and without any great temperature rise. The cool compressed air absorbs more than enough heat from the exhaust gases to balance the cooling loss in the compressing outfit and the engine gains at least by the work required for such hot compression over the cool. The saving is a recovery from the exhaust and it is possible that a further saving is sufficient to replace some heat of combustion that would otherwise be required to develop a given amount of power.

Another point here seems to work to the advantage of Mr. Stilz's design. A certain weight of air is needed to insure proper combustion; with hot compression this involves pumping a greater volume at the same pressure with greater work. The air supply for Mr. Stilz's engine by some may be held to be expanded and heated also, by the time it reaches the fuel, but such expansion work and heating is done at the expense of the exhaust.

There is a little data to support the belief that a more efficient heat liberation occurs at constant-pressure combustion than at constant-volume. This field has not been thoroughly explored, but the discrepancies are generally explained as due to a change in specific heat after successive chemical and molecular changes, to dissociation of gases at the higher temperatures without recombination before exhaust, etc.

Thus it can be shown that the thermodynamic efficiency of an internal combustion engine is increased: (1) if the working medium is compressed with the least possible rise in temperature to allow greatest possible recovery of heat from the exhaust gases; and (2), if the combustion is complete and at constant pressure.

Naturally, an engine to utilize such processes will be inherently more complicated than a small four-stroke cycle farm engine which has been stripped of every possible complication, to insure reliable operation in unskilled hands. If such a design, as made by Mr. Stilz, be compared with the modern, high-power, explosion-engines with automatic compressed-air starting attachments, complicated valve gear, forced-lubrication apparatus, gas-pressure regulators, etc., then the constant-pressure engine has no more secondary working parts than the explosion type.

It has been recognized of late that the design of large explosion engines, for driving alternating-current generators, needs more careful study on one point, if their use in electric power plants is to increase satisfactorily. It is now held that a close enough approach to constant angular velocity of the generator rotors is not given by planting several impulses on the revolving mass during a revolution. Such slight but sharp angular variations introduce harmonics into the sine wave of e. m. f. that would result if the generator ran at truly constant angular velocity. Such slight sharp ripples of voltage in themselves are not marked enough to prevent parallel operation of generators and they may be entirely unappreciated until there is some change in the electrical properties of the various circuits which allows these higher-frequency ripples to become cumulative. When such resonance is reached one may expect abnormal voltages and heavy local currents, destructive in effect and puzzling to remedy. Such changes in circuit conditions are liable to occur in switching heavy currents at high voltages, in minor short circuits and in arcs to ground.

When an explosion occurs against a rigid mechanism, like the combination of a piston, rod, crank and fly-wheel, sharp though perhaps slight variations of fly-wheel speed must occur and it must be admitted that the development of non-explosion internal-combustion engines is desirable. This brings us back to the smooth operation of a steam-engine drive, where explosion-fathered harmonics are not found,—a drive which seems possible with a multiple arrangement of constant-pressure combustion cylinders.

LETTERS TO THE EDITOR.

Professorial Research and Editorial Iconoclasm.

Sir: On the editorial page of your issue of March 11, I have just noted your unfavorable criticism of the paper by Prof. Nicolson, as published in "Engineering," relating to the experimental determination of "Heat Transmission in Steam Boilers," in terms of the velocity of gases as referred to the heating surface. The objections of the editorial "engineer" to "professorial" engineering and "research," and to this paper in particular, apparently are: that engineers do not study this class of material; that it bristles with mathematics and seven-term equations; that Rankine's formula is more simple, although known to be crude and inexact; that the learned gentleman's conclusions with reference to draft are erroneous; and, in any event, that all of our boilers from the antiquated "haystack" of 1809, to the smoking modern horizontal water tube of 1909, and inclusive, were designed by "hard headed" (and sometimes thick headed) engineers, without reference to the laws of heat transmission other than as derived from "practical" common sense.

Now regarding the first item at issue, it is the opinion of the writer that the ordinary practicing engineer is very much interested in the quantitative laws of heat transmission; and it has been his experience to find a dearth of material on this subject in the usual sources. When the engineer has to design an air or water heater, a condenser, an economizer installation, boiler, etc., to operate under conditions differing slightly from the ordinary, it is very difficult to predict, with even approximate accuracy, the final result. A knowledge of the influence of the fluid velocity is important and desirable, for instance when "indirect" methods of house heating or similar problems are considered; and several manufacturers of such apparatus in this country have investigated the subject, to an extent at least sufficient to satisfy their own needs. Such matter, however, has not usually been available to the ordinary practicing engineer.

That the formula contains seven terms is admitted; and while it is a very simple one, it is neither more nor less valuable than if it were complex, if we disregard its convenience; and if it correctly expresses the

quantitative relations as they exist among the several factors, it is a distinct addition to the literature of a subject that has thus far been much neglected.

An elementary consideration of the ordinary practice in furnace draft and boiler baffling, will show that no solid fuel need be lost by way of the chimney, even with the 10 or 20 ins. of draft proposed. The ordinary draft of ¼ in. or more, over the fire, need not be increased, whereas the necessary pressure difference to produce the flow through the several "passes" of the boiler depends entirely upon the dimensions and arrangement of those passages. The results from increased velocity, up to a certain point, will show a gain, either in efficiency, when both heating surface and gas quantities are maintained constant; or in capacity, when the increase of velocity is due solely to a greater volume of gas. Some information on these points is to be found in the works of Prof. Perry, the publications of the U. S. Geological Survey, and elsewhere.

Considering the not very well-known fact, that in this country in the utilization of bituminous fuel, more steam boilers operate below than above 55% efficiency of boiler and furnace, due in part to neglect of opportunity by the self-styled "practical" engineer, should not the real practical engineer welcome any true information on this subject, whether simple or complex in form?

Yours very truly,
E. P. Coleman.

Buffalo, N. Y., April 12, 1909.

Standard Methods for Bacteriological Examinations of Water and Milk.

Sir: Recently in examining and comparing the bacterial efficiencies of two filter plants, the writer was at a loss to know how greater efficiencies were secured at one plant than at another, when the conditions surrounding the two plants were such as to warrant a higher efficiency from the one that showed the lesser efficiency.

An investigation of the method of making the analyses at each plant disclosed the fact that where the higher results were obtained the bacterial count was made on cultures with 48-hr. incubation; while at the other plant the count was made after a 72-hr. incubation. Based upon a 48-hr. incubation, the percentage of bacterial removal has been uniformly 100 at the plant which seemingly gave the poorer results.

Not long ago the writer's attention was called to an address delivered by a noted bacteriologist, in which he pointed out that there is such a lack in the standard methods of bacteriological investigation, that two bacteriologists could examine the same sample of milk and, from their examinations, one would report a bacterial count of 12,000 bacteria per cubic centimeter, while the other would report a count of 500,000. Is it not possible to secure some concerted action on the part of those interested, so that the results stated can be relied upon as meaning the same thing to all?

Yours very truly,
Alexander Potter.

143 Liberty St., New York City.

[For some years past the Laboratory Section of the American Public Health Association has had committees on standard methods of analysis of water, sewage and milk. These committees have made a number of reports, in which bacterial and other standards were recommended. The names of the members of the special committees can doubtless be obtained from Dr. C. O. Probst, Secretary American Public Health Association, Columbus, O.—Ed.]

Waste of Water in New York City and Elsewhere.

Sir: Continuing the comments to be found on p. 387 of the Engineering News, let me ask: of what value is a study of the average consumption in a lot of the ordinarily shiftless, mismanaged cities of the U. S. in determining the proper amount of consumption of water for domestic purposes? Should not statistics show also the *degree of care and thrift* exercised by each city? Should not the *true* average result be sought; one which would give *weight* to each city record, according to the degree of good housekeeping exercised by it?

Thus: Buffalo, with its 400 gals. per-day-per-inhabitant record of pumping into a sieve of open faucets and probably leaky street mains as well, should have its statistical figure multiplied by zero, as teaching nothing, except how *not* to do it; while Providence, R. I., a 200,000-inhabitant, hitherto well-managed, American city, should have its 60 gals. per-day-per-inhabitant statistical figure multiplied by say 100; in each case to use in a computation leading to the true and proper average to be found.

If Providence, in the course of time, became endued with the common disease of preferring the glory of an "extending of the water-works" to the hard and inglorious routine work of striving for a saving of amounts wasted, its attributive and characteristic figure would have to be changed. So far it has been good, and one to pattern by.

Not until all water supplied to a city and consumed within it is measured *continuously*, night and day, and a daily balance between such income and outgo is sought for, and it is also made the *profit* of every consumer not to waste, will the "conservation" of domestic water-supply begin to receive the proper attention and take the proper form, in American cities.

2 Wall St.

April 15, 1909.

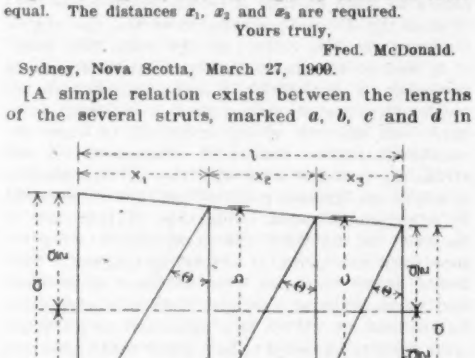
Panel-Lengths for Equal Slope of Diagonals Between Converging Chords.

Sir: I would like to have a solution of the following interesting problem; a brief one preferred. It is as shown on the diagram below. The distances a and d and the length l are given, and the angles θ are to be made equal. The distances x_1, x_2 and x_3 are required.

Yours truly,
Fred. McDonald.

Sydney, Nova Scotia, March 27, 1909.

[A simple relation exists between the lengths of the several struts, marked a, b, c and d in



the diagram. They have a constant ratio, i. e., $a/b = b/c = c/d$. Since a and d are known, the values of the others are:

$$b = \sqrt[3]{a^2 d},\ c = \sqrt[3]{a d^2}.$$

From these widths and the known convergence of chords the panel-lengths may be calculated. The same relations hold for any number of subdivisions. Thus, if five panels are to be put in on the length l, with end widths a and f, the intermediate post lengths are

$$b = \sqrt[4]{a^3 f},\ c = \sqrt[4]{a^2 f^2},\ d = \sqrt[4]{a f^3},\ e = \sqrt[4]{a f^4}.$$

Or the panel-lengths may be computed directly by the following relation derived from the above. For the above case of five panels, calculate the value

$$r = \sqrt[4]{\frac{f}{a}}$$

Then

$$x_1 = \frac{l}{1 + r + r^2 + r^3 + r^4}$$

$$x_2 = x_1 r$$
$$x_3 = x_1 r^2$$
$$x_4 = x_1 r^3$$
$$x_5 = x_1 r^4$$

Check: $x_1 + x_2 + x_3 + x_4 + x_5 = l$.

Possibly a graphical solution can be worked out from these relations, but it is likely to be much less simple than the computation.—Ed.]

Subdividing an Arch Ring for Stress Analysis.

Sir: There seems to be some confusion regarding the calculations required in dividing up an arch ring so as to make $\frac{\delta s}{I}$ a constant, as explained on p. 272 of "Principles of Reinforced Concrete Construction," of which the undersigned is joint author. The method there described can be best understood by reference to a graphical representation of the quantities involved. The notation is as follows:

I = moment of inertia of arch ring at any section;

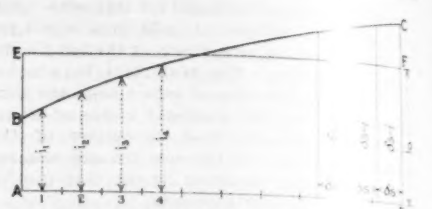
i = reciprocal of I, or $i = \frac{1}{I}$

i_a = mean value of i as described below;

s = half length of arch ring measured along the axis;

n = desired number of divisions of one-half the arch.

δs = length of any subdivision (generally all different).



In the diagram (see sketch herewith) lay off a base $A\ D = s$ and divide this distance into 10 equal parts, numbered 1, 2, 3, etc. At the center point of each subdivision erect an ordinate equal to the value of i for the corresponding point of the arch. Draw the curve $B\ C$. Calculate the mean value of i from the values just obtained; this is i_a. Draw the line $E\ F$ so that ordinate equal to i_a. Then by construction area $A\ B\ C\ D$ = area $A\ E\ F\ D$.

The area $A\ B\ C\ D$ is now to be cut up into n equal areas. Let δs represent in general the base width of such area and i its mean ordinate. Then each area = $i\ \delta s$, and $n\ i\ \delta s$ = area $A\ B\ C\ D$ = area $A\ E\ F\ D$ = $s\ i_a$. Hence $i\ \delta s = \frac{s\ i_a}{n}$. The value of the area $i\ \delta s$ therefore becomes known and, beginning at A or D, the several equal areas can readily be laid off in succession, the values of i being scaled from the diagram (or interpolated) as we proceed.

Yours very truly,
F. E. Turneaure.

University of Wisconsin, Madison, Wis., March 26, 1909.

Proposed Water-Pollution Legislation in New York State.

Sir: I understand that a bill has been introduced in the Assembly of this State giving the State Commissioner of Health power to prohibit the discharge of sewage and manufacturing waste into streams of the State. As I understand it, this bill, if it becomes a law, will give the Commissioner absolute power to prevent any city or any manufactory from discharging anything into any waters of the State. It is, of course, entirely questionable whether such a law would be constitutional.

In the midst of all this popular and often ignorant denunciation of sewage disposal by discharge into neighboring waters it is well to emphasize the fact that large streams, from the nature of things, always have been and always will be sewers. When the country was not as thickly settled the sewage was small in amount and rivers were purer. As the valleys become more settled naturally more storm water with the street leavings of cities or towns is discharged into the streams; and this must always be so. Even if the house sewage be purified, no one could expect cities or towns to catch all the storm water and purify it. In some cities it would be a matter of great complexity and great expense to purify even the house sewage before discharging it into a river, without considering the storm water. Even if the house sewage were purified in all the villages and towns along a stream, such stream might and probably would be totally unfit for people to drink unless it were filtered; this on account of storm water discharged from the towns and cities and the possibility of pollution from farms in thickly settled districts.

The enforcement of the rule that all sewage must be treated in a thickly populated valley would entail excessive expense and after that expense had been borne further expense for filtration would properly have to be incurred by any town or city using the water of the river. The Mohawk Valley is an illustration. As a matter of fact, most towns and cities are so situated that they may obtain water from adjacent hills before it reaches a river or they may obtain it by sinking wells along the banks, so that there are not a great many cases where cities are absolutely compelled to take water from an adjacent river.

Considering the great expense entailed in treating sewage in large quantities and the fact that storm water discharge in thickly-settled districts will always make a river a sewer, it seems to me that the agitation against the use of rivers as sewage carriers is going too far. It goes without saying that the smaller streams should not be permitted to become in any way offensive by the discharge of sewage into them. For instance, they should seldom if ever be allowed to become so bad that cattle will not drink from them. Cases are very rare, however, in which rivers are polluted to anything like this extent.

There are two sides to this sewerage question from a health point of view. If sewage cannot be easily gotten rid of and if restrictions are constantly being thrown in the way of its easy disposal, the results may be far more serious to a community than the pollution to a slight extent of a stream which may not be used for a city water-supply during any portion of its length.

One thing more. As countries become more thickly settled and social conditions become more complex, gov-

ernment by commission properly becomes more and more necessary. Such government if carried too far is, in my opinion, fraught with very serious evil. It may result in much arbitrary action and much injustice. I believe that this sewerage question should not be summarily settled by one man whose rulings are, and should be, difficult to overthrow. It is time for the authorities of the many cities of this State with sewage discharging into neighboring waters to wake up and not let any arbitrary and drastic law be passed which may seriously and unjustly affect their communities.

Respectfully,
Palmer C. Ricketts.

Rensselaer Polytechnic Institute, Troy, N. Y., April 5, 1909.

[Leaving for the moment our correspondent's reference to the legislation now pending at Albany, we note that his general argument for a rational view of sewage disposal is in line with what has been urged by this journal for a number of years past; also that it is in general accord with the remarks by Mr. John R. Freeman before the recent joint meeting of the four national engineering societies (see Eng. News, April 1, 1909, p. 362).

As to the pending legislation (or at least a bill introduced in the Senate by Mr. Burlingame on April 5) it is not as drastic and gives no one man so much power as President Ricketts seems to understand. Prohibitions of sewage discharge or orders for purification must be based on investigations by the State Commissioner of Health, followed by the formation of an opinion that a continuation of the discharge, without purification, would be "injurious to or a menace to health or comfort," *but* such orders would not be effective unless approved by the Governor and Attorney-General. This refers to sewage from old sewerage systems, municipal or industrial. For new systems, or for increases in the discharge of sewage from old systems, it appears that the proposed amendatory legislation would leave the plans for new work wholly within the control of the Commissioner of Health, as now. He would continue to have power to permit the discharge of untreated sewage into natural waters, "whenever in his opinion the general interests of the public health would be subserved thereby."

The proposed legislation, as well as that already in force, is similar to laws passed recently by a number of states, except that the state health department has sole jurisdiction in some states, instead of acting jointly with the Governor and Attorney-General in issuing some of his anti-pollution orders. It should be noted, however, that New York and Pennsylvania are the only states which have one-man health departments. Pennsylvania orders compelling sewage purification must also be approved by the Governor and Attorney-General. The same is true under the Ohio legislation of a year ago, and in addition appeals to boards of engineers may be taken in the case of Ohio orders. The Ohio plan of engineer-arbitrators has been adopted in some of the legislative bills of the present year.

"Government by commission," as President Ricketts says, is becoming "more and more necessary." Like most other good things, it can be carried too far, but it is utterly useless to create administrative commissions without giving them power to enforce their orders—or else so vesting that power somewhere else as to ensure its prompt and effective use.

Finally, as to the concluding sentences of President Ricketts' letter, we think that an enlightened public opinion should be brought to bear on the sanitary authorities of New York and other states, whenever and wherever necessary, rather than attempting to thwart any water-pollution legislation which has thus far been promoted with chance of success.—Ed.]

The Alien Labor Law and the Engineer.

Sir: The writer was rather amused to read your editorial of March 18, p. 299, regarding Canadian import duty on engineers' and architects' drawings.

If Canada is 70 years behind the times in her attitude towards alien designs, none can deny but that she is progressing, and not retrograding, as a recent experience leads us to believe to be the case with her southern neighbor.

During the past week a warrant for deportation has been issued by the U. S. Department of Commerce and Labor which will mean the forced return to Canada of a bright and ambitious young engineer. This is on the ground of a violation of the alien labor law. As Uncle Sam does not recognize officially engineers as professional men, and only exempts from this ruling actors, artists and ministers we may expect to see the ablest men from other countries barred in future. They will not be allowed either to design or supervise, but must convey their thoughts by other duty-free means.

In the early industrial history of the United States, every effort was made to encourage ambitious men of energy and ambition to settle here, but to-day we have apparently reached a position where we do not require outside talent.

A duty on drawings is but a minor issue as compared with the absolute prohibition of engineering talent from the country. Do you not think you should condemn both governments equally in these short-sighted policies and not attempt to cast out the mote from your brother's eye before you advocate the removal of a few beams from our own?

"Cosmopolite."

Schenectady, N. Y., April 2, 1909.

[For the benefit of those of our readers who are unacquainted with the Alien Labor Law we quote below that portion which concerns the case noted by our correspondent. The italics are our own.

. . . The following classes of aliens shall be excluded from admission into the United States: . . . persons hereinafter called contract laborers, who have been induced or solicited to migrate to this country by offers or promises of employment or in consequence of agreements, oral, written or printed, express or implied, to perform labor in this country of any kind, skilled or unskilled. . . . Provided, that the provisions of this law applicable to contract labor shall not be held to exclude professional actors, artists, lecturers, singers, ministers of any religious denomination, professors for colleges, seminaries, *persons belonging to any recognized learned profession*, or persons employed strictly as personal or domestic servants.

In order to investigate the charge made by our correspondent we referred his letter to the Bureau of Immigration and Naturalization of the U. S. Department of Commerce and Labor. From the Bureau we have received the following information:

It is assumed that the case referred to by your correspondent was that of . . .[a Canadian], rejected at Newport, Vermont, March 10, 1909, as a contract laborer. This man, according to the evidence placed before the Bureau in connection with his appeal, was attempting to enter the United States in pursuance of a contract to act as a business solicitor and to prepare estimates for street paving for an American corporation. While the evidence showed that the man had some knowledge of civil engineering, it did not show that he was a member of that profession, or that he was being imported for the performance of engineering work. The work he was to do required some knowledge of engineering, but apparently was to consist chiefly of soliciting business for his employers. *The Bureau did not hold in that case nor has it held in any case that a civil engineer is not a member of a learned profession* within the meaning of the proviso [noted above] of the Immigration Act.

So this particular beam will not interfere with our mote-removing activities.—Ed.]

Notes and Queries.

V. R. C., Pittsburg, Pa., writes

Inquiry has recently come to this office concerning the use of the "cord" for measuring stone, and I have been unable to get any information concerning it from any books of reference. A letter, written to an old resident of Northeastern Ohio, brings the information that this unit is in common use there for cellar-wall stone and rough rubble and is identical with the cord of wood, containing 128 cu. ft. The authority for its use is "Ray's Third Part Arithmetic," which was a text book in common use some forty or fifty years ago. How extensively is this unit in use?

We presume the cord of stone is still in general use in country districts in paying teamsters for hauling rough stone.

A correspondent writes:

Are you able to give me any information in regard to the action of septic sewage on concrete?

For more than a score of years concrete has been a standard material for sewers and septic tanks, a material which is admirably suited for the purpose else its use would not be continued. Of late, however, certain of the anti-concrete interests have published considerable matter purporting to show the disintegration of concrete in sewer pipe, presumably under the destructive action of the sewage. While such publications are not authoritative, both on account of the partisan nature of their source and on account of the limited information they contain descriptive of the cited instances, still it must be said that the case for the durability of concrete in sewage is largely negative. That is, no unprejudiced observer has reported that concrete has disintegrated under contact with sewage, but, so far as we know, neither have there been any experiments or even observations reported which prove that concrete will not so disintegrate.

The material could not have been so widely used in sewers and septic tanks for so long a time if it had proved unsuited to such use, but the case in its favor would be much stronger if positive experiments and observations were adduced. If such information is available we would be glad to give it publicity.

A letter from a Pacific Coast city is worth quoting, "Verbatim et literatim," omitting names:

As we are incorporated the ——— Company which controls the patents of opperating street ans surburban electric roads by the means of a new system of transmitting electricity too cars. . . . . Thereby doing away with the ware and tare also the danger of the overnead trolly and the ecomony of operation.

Another letter in the same mail calls our attention to a publication describing a very large bridge. The writer informs us that "The enormity of the work is fully set forth."

Perhaps the typewriter (either feminine or neuter gender) was responsible.

The Panama Canal and the Navigator.*

Although the type of canal at Panama is probably definitely settled in favor of the lock system, there continues to be more or less agitation and discussion of the subject not only in the daily press but to some extent in the technical press, though it must be said that the latter almost unanimously support the decision in favor of the lock type. The opposition to it comes chiefly from a few engineers whose opinions were not given the weight to which they seem to think they were entitled and some of whom are interested in special methods of prosecuting such work.

So far the men who are to use the channel seem to have been overlooked but it is they, and not the engineers, who will justify or confound the judgment of those who determined the type. We need not here discuss the arguments advanced by each side but will consider both types as they affect navigation.

The total length of canal is approximately 50 miles; in the sea level type about two-fifths of this is made up of curves, in the lock type about one-seventh. In the sea-level type these curves are sinuous; in the lock type they merely represent the center line of the canal at the intersection of straight portions, or ranges. In actual navigation the ship is kept steadily on one range until she closes the range on the next course, and where these shifts of wheel occur the channel is widened by the suppression of the interior angle to give abundant room to swing or pass another ship.

It is impossible to steady a ship on a constantly changing course, even in daylight, because there is nothing to steady her by, leaving out of the question the influence of bottom drag of which we will speak later, and in this the army engineers who have had the benefit of long experience in laying out, constructing and maintaining ship channels as actually demanded by navigation, have evidenced the value of their experience. Navigation of such a channel at night, when even the bank is not visible is entirely impossible, whereas straight reaches with simple range lights are as easily negotiated by night as by day, so long as the lights can be picked up, even with a glass. Of course ranges on curves are not feasible and lighted buoys in a curving channel are altogether impracticable.

In width of channel the proposed sea-level type is little more than a continuous ditch, with a bottom width of 150 ft. The lock type has a least bottom width of 300 ft. and this for only about eight miles; for about 22 miles, 500 ft. width and for about 20 miles across Gatun Lake, it will be from 800 to 1,000 ft. wide. These widths allow even in the shallowest portions, of a considerable amount of swing, and human power has not yet been able to prevent this swing in narrow or shallow channels, even with no current. The narrower the channel the greater the tendency to swing, and as the ship always makes for the nearest bank, when "hunting" is once begun, it becomes increasingly more difficult to arrest, because of the increased angle of helm necessary to steady her. Passing other ships in such a channel is a matter of most serious difficulty, because the cross section of the two ships is such a large proportion of the total channel section that violent disturbing eddies and currents are set up, chiefly by propeller action, and it is very doubtful indeed if two 60-ft. beam ships, with the most careful and deliberate handling, could pass each other in a 150-ft. channel without rubbing.

One of the advocates of the sea-level type in a letter to Engineering News gravely states that the tidal currents set up in the canal and reaching about 3 miles per hour, calculated on the entire area of cross-section of canal, would be no hindrance to navigation. He quotes instances of navigation in much higher currents, such as the lower Mississippi in flood, the North River at New York and some tropical streams navigated by flat-bottomed light draft boats.

It is almost a waste of space to point out that maneuvering or steering a ship in a current is almost entirely a question of the relative volumes of the ship

*Condensed from an editorial in the "Marine Review" for April.

and the stream. A ship which could be driven and steered at full speed up North River in any current could not be driven one foot at full speed (as actually suggested) in a canal or narrow stream. For that matter a ship of say 60 ft. beam and 28 ft. draft could not be driven 100 yards in the proposed sea-level canal at full speed, even with no current whatever. And as a ship can only be steered as she has motion relative to the surrounding water, a vessel traveling with a 3-mile current would necessarily have an actual speed of something over that in order to have steerage way, say an additional 3 miles.

The control of such a ship in a sea-level canal under such conditions, to say nothing of meeting other ships, in a channel only 150 ft. wide and at which point the current is consequently greatly accelerated, is something which only a man devoid of practical knowledge would consider without a shiver.

The author of the letter referred to quotes the Detroit River as an instance of navigating in a 4-mile current. There is no point in the Detroit River where such a current exists, but even admitting that it does it has no bearing on the case whatever. The Detroit River is wide, and except for a short distance at the lower end, relatively deep, so that speed is affected very little and except at one point, steering not at all, and this point is always navigated at slow speed.

The time occupied in lockages is more than made up by the greater facility of navigation in the lock canal but this time is not nearly so great as seems to be supposed. The average lockage at the Poe lock at the Soo is about 40 minutes, and although the locks at Panama are slightly larger than the Poe, the arrangements for filling and emptying will doubtless be in proportion, and probably better, so that the three lockages should not consume over three hours at most. The author referred to also speaks of the experience with accidents to locks at the Soo, while as a matter of fact there have been none of any consequence in the entire 54 years, as we have had occasion to note in a previous issue. We question if a navigator can be found who, when he fully understands both plans, will not unhesitatingly declare for the lock type, even though he may never have done any locking, while to those who have the problem has no terrors.

A Complicated Reinforced-Concrete Jetty-Head, Thames Haven, Eng.

As an indication of the tendency in European reinforced-concrete practice to complicate reinforcement and connections far beyond what would be called sane design in this country, we produce here some views and a short description, taken from the March, 1909, number of the London "Concrete and Constructional Engineering" illustrating a new jetty-head just built at Thames Haven, England, near the mouth of the River Thames.

The new structure has been built to replace an old T-head composed of cast-iron piles with wrought-iron bracings, the greater portion of which was carried away in a collision by a large vessel. After the collision, part of the old structure remained, and this, with the addition of temporary wood piles, was used as staging from which to construct the new work. The jetty head is 136 ft. long by 32 ft. wide. The deck level is 5 ft. 6 ins. above high water spring tides and about 45 to 48 ft. from the bed of the river; the spring tide range is about 18 ft. Vessels up to 8,000 tons burden are accommodated, so that the structure was needed to be especially strong in cross section, in order to take the shock resulting from such large vessels. The jetty head was required to be designed as a complete structure in itself and independent of the approach jetty, which could not be reckoned on for support. It being impossible to fix concrete bracing below low water level it was decided to make the main support of the structure composed of two piles, which were surrounded by a reinforced-concrete cylinder 5 ft. in diameter, and then filled in solid, so as to give great lateral stiffness to each support. A general plan and elevation is shown in Fig. 1. There are three main columns in the width of the structure, the center column being midway between the outer columns, with horizontal and diagonal bracing in all directions.

The columns are 5 ft. diameter up to low water, above which they are reduced to an oval section of about 5 ft. x 2 ft. 6 ins. and continued in this section up to the under side of the deck. All the horizontals and diagonals are also spirally and longitudinally reinforced. Timber fenders are bolted to the columns to act as rubbers against the jars of ships.

In the construction, piles 45 ft. long were driven 18 to 20 ft. into the bed of the river in groups of two. The temporary steel casting was then dropped over the piles and bedded about 2 or 3 ft. into the bed of the river. Inside this steel casing and over the piles an enveloping reinforcing composed of longitudinal rods and hoops, was dropped, and the casing was filled up with a 1:3 concrete, deposited through the water by means of chutes, to 3 ft. above low water level. The columns, braces and deck were then built in place with the usual timber forms.

The temporary steel casing around the piers was made in two halves, with vertical joints bolted together, so that it could afterwards be taken away, when the concrete was set, by means of a diver unbolting the vertical joints. The piles were 15 ins. diameter octagonal section, made on the Considere principle; the reinforcing was composed of ⅜-in. steel, spirally wound with 2-in. pitch, and 8 longitudinal rods of 1-in. diameter. The strata of the ground into which the piles were driven is composed of Thames gravel, with an overlay of about 4 to 6 ft. of soft, sandy mud.

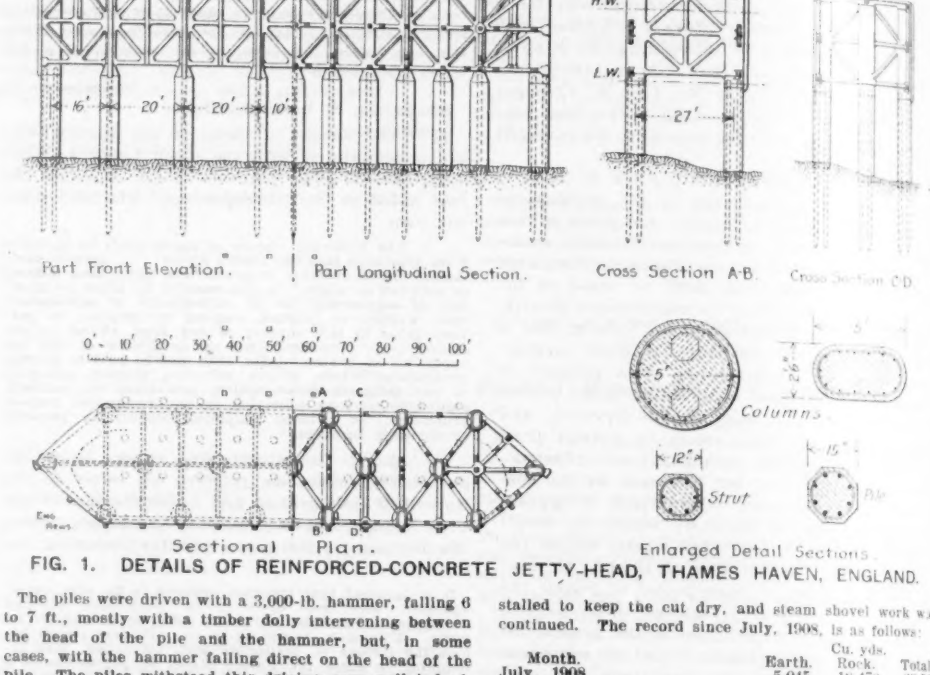


FIG. 1. DETAILS OF REINFORCED-CONCRETE JETTY-HEAD, THAMES HAVEN, ENGLAND.

The piles were driven with a 3,000-lb. hammer, falling 6 to 7 ft., mostly with a timber dolly intervening between the head of the pile and the hammer, but, in some cases, with the hammer falling direct on the head of the pile. The piles withstood this driving very well indeed, and, where the dolly was used, the head did not suffer in the least, although, in some cases, the piles were driven to a set of 100 blows for the last inch before they were regarded as being driven to refusal. In the cases of direct driving, without any dolly at all, the piles were simply broomed up for about 12 ins. of the head in a similar manner to timber piles.

The cost of the entire structure, including considerable work in removing the old jetty was about $22,000.

Fig. 2 shows a view of one of the piers, formed from a basis of two reinforced-concrete piles, together with the multitude of braces concentrating at the base of the pier. From the view of the finished joint a remarkably good piece of concrete work has been accomplished, but the tangled mass of steel shown in the preliminary view hardly inspires confidence in the condition of the interior of the joint, nor does the connection of steel to steel look especially strong. Note should be made of a somewhat similar style of construction shown on another page of this issue in the description of the Avranches Bridge, and of the editorial comment on this tendency toward imitating steel and wood details in reinforced concrete.

FIG. 2. VIEW OF A PAIR OF PILES AND BRACE INTERSECTION, BEFORE AND AFTER CONCRETING.

Rock Excavation on the Atlantic Division of the Panama Canal*

From the shore line of Limon Bay inland for two miles the channel runs through a bed of silt overlying argillaceous sandstone.

The excavation in the Mindi Hills begins at the point where the present Canal crosses the old French canal and extends south a half mile. A channel 500 ft. wide has been cut through a hill about 50 ft. high, and in August, 1908, after a year of excavation the cut had reached sea-level. Instead of blasting the rock below sea-level, flooding it, and taking it out by dipper dredges, as was at first intended, two pumps were installed to keep the cut dry, and steam shovel work was continued. The record since July, 1908, is as follows:

Month.	Earth.	Rock.	Total.
	Cu. yds.		
July, 1908	5,045	18,470	23,515
August, 1908	10,552	5,757	16,309
September, 1908	10,759	21,353	32,112
October, 1908	6,383	39,092	45,475
November, 1908	10,991	36,192	47,183
December, 1908	14,559	47,694	62,253
January, 1909	8,096	37,568	45,664
February, 1909	7,951	38,095	46,046
March, 1909	.....	.....	70,713
Total	74,336	244,221	389,270

The total amount of material to be excavated at Mindi when work was begun in July, 1907, was about 2,800,000 cu. yds., and 927,229 cu. yds. had been taken out on April 1, 1909. In July and August, 1908, only one 70-ton shovel was constantly at work, and between August and March two 70-ton shovels were operated.

Since the first week in March two 70-ton and one 95-ton shovels have been working at this point, and one of the shovels is 24 ft. below sea-level. Only rock is excavated, as it is more economical to allow the earth to be taken out by dredges, which will be done when the rock excavation is finished and the cut is flooded. The spoil is dumped on the relocated line of the Panama Railroad at Gatun, on the toes of Gatun Dam, and one trainload a day is sent to Colon to be used in various fills in process there. Three pumps are ready for use in keeping the cut dry, but up to the present time one has generally been found adequate.

From the shore line to the hills at Mindi the work is

*From the "Canal Record," April 7.

being done by dredges. Subaqueous rock excavation, usually very expensive, is done here for less than $1 a cubic yard. Holes are drilled in the rock which are blasted without stemming with 60% dynamite. This blasting has been done so successfully that the rock is shattered into pieces small enough to be handled by the ladder and dipper dredges. The channel must be 40 ft. deep below mean sea level at the Atlantic entrance, and the lowest point reached at present is 38 ft.

This excavation is being done by two reconstructed Scotch ladder dredges left on the Isthmus by the French, and two modern clipper dredges. The ladder dredges handle material to a depth of 20 to 25 ft. readily. It is intended to remove the bottom rock by the dipper dredges.

Specifications and Bids for a Refuse Incinerating and Power Generating Plant for Milwaukee, Wis.

Milwaukee has now joined the small but somewhat rapidly increasing number of cities that are handling their garbage and refuse disposal matters in a business-like and engineering manner. We give below an abstract of the specifications for a 300-ton incinerating plant for burning mixed refuse, together with a tabulation of the detailed bids for the plant received on March 31.

In our issue of Jan. 16, 1908, we published an abstract of an important report on refuse collection and disposal at Milwaukee, made by Mr. Rudolph Hering, M. Am. Soc. C. E., of Hering & Fuller, 170 Broadway, New York City. The engineering firm just named has since prepared specifications named just above, accompanied by general plans, and since the opening of bids on March 31 a contract for the plant has been awarded by the Board of Public Works, on the recommendation of Mr. Hering, to the Power Specialty Co., of New York City. The furnaces to be erected under this contract will be of the Heenan & Froude type, which has in comparatively recent years come into extensive use in Great Britain and one of which was recently installed at West New Brighton, Borough of Richmond, for the City of New York (see Eng. News, Nov. 5, 1908).

The Board of Public Works of Milwaukee has the following membership: Messrs. Charles J. Poetsch, J. P. Sherer, L. A. Jansen and A. J. Grundman. Mr. Samuel A. Greeley has been selected by Hering & Fuller to act as resident engineer in the construction of the Milwaukee plant.

The incinerating plant will be located at the foot of Erie St., near the point where the Milwaukee River enters Lake Erie. The mixed refuse, consisting of garbage, household ashes, rubbish and manure, will be brought to the plant in removable wagon boxes. These boxes will be lifted by electric traveling cranes and their contents deposited in reinforced-concrete storage hoppers. Provision is made, in connection with the hoppers, for draining off the liquid contents of the garbage. The furnaces will be of the top-feed type.

The contract is for the refuse incineration plant complete, with all accessories. It includes the foundation of a building to house the plant, reinforced-concrete storage hoppers, and apparently concrete or reinforced-concrete floors for the building, but does not include the superstructure of the building.

Provision is to be made for mixing the refuse before feeding it to the furnaces, and also for drying wet garbage before it is burned and for forced draft by means of air heated to at least 300° F. The products of combustion are to pass through a combustion chamber, and thence through water-tight boilers and pre-heaters. The specifications state:

> It is expected that the excess of steam generated in the boilers will be used by the city for power and that the residual clinker and ash will be used for road-making, concrete or other purpose.

A positive system of ventilation for the whole building must be provided, so arranged to draw

> the air for combustion through ducts from the upper portion of the feeding and clinker rooms and from above the hoppers so as to cause a continuous upward movement of the air in the building and allow air from the outside to enter the lower part of the building, and to force the dust, smoke and odorous air through the fires where they shall be consumed and the resulting gases pass out through the chimney. It is an essential requirement that no dust or smoke shall escape to the outside of the building.

A requirement of the specifications outlining in a general way what the plant is to be, is as follows:

> It is required and it is essential that when burning the refuse at or about the rated capacity of the plant of 300 tons per 24 hrs., the process will be carried on without nuisance from dust, smell or smoke at an average temperature in the combustion chamber of 1,500° F., as ascertained from a continuous record, and a minimum of not less than 1,250° F. There being considerable variation in the character of the refuse as collected from month to month, and more especially between summer and winter refuse, it is required that the furnace meet these varying conditions in a simple, practical and thoroughly effective manner. It is further required that the plant consume the refuse at a uniform rate through the 24 hours and that the temperature shall be substantially uniform and continuous while the plant is in operation.

The incinerating plant is to be arranged in four units, each unit to consist of two furnaces, a combustion chamber, a pre-heater, a forced-draft apparatus, a water-tube boiler, flues, tools and recording instruments. Each unit must have a capacity of 75 tons of refuse per 24 hrs. and must be fitted with a drying hearth. To serve the whole plant there will be provided a feed-water heater and two feed-water pumps. The furnaces and combustion chambers will be built of hard-burned brick and lined "with the best quality of fire brick, laid with the closest possible joints of fire clay." The furnace grates are to be of cast-iron, "with suitable air space and with provision for expansion and contraction."

The boilers are to be able to stand a working pressure of 180 lbs. and to have a capacity of 200 boiler HP. One boiler HP. is defined as representing "an evaporation of 30 lbs. of water per hr. from a feed-water temperature of 100° F. into steam at 70 lbs. gage pressure." Each boiler is to have a water heating surface of 2,000 sq. ft.

The contractor is to furnish all necessary firing and clinkering tools, barrows, cars or other conveyors for removing ashes and clinker, and various minor tools; also recording instruments as follows:

> The contractor shall furnish eight draft gages for recording ash-pit pressures; one Fery radiation pyrometer, or its equivalent, with continuously recording outfit; one Bristol electric indicating pyrometer, or its equivalent, with continuously recording outfit; a sufficient number of proper thermometers for recording the temperature of the outside air, the pre-heated air and the chimney gases; one continuous carbon dioxide (CO_2) recorder of the gravimetric type; one 4-in., size F, St. John self-recording steam meter, or its equivalent; and one 2-in., size B, St. John self-recording steam meter, or its equivalent. The proper connections for all of these instruments shall be provided and fitted to each unit. Suitable and sufficient paper charts to last one year shall be provided with each self-recording instrument.

There will be two reinforced-concrete storage hoppers, each with a capacity of about 400 cu. yds. Each hopper will be divided into three bins, one for light combustible material and two for other material.

The electric traveling cranes called for by the specifications will be two in number, each of 3 tons capacity and each provided with three motors. The main hoist, for lifting the boxes, will be driven by a 10-HP. motor, the trolley by a 2½-HP. motor and the bridge by a 5-HP. motor.

The plant is to be lighted by electricity, the apparatus for which, as well as the motors for driving the four fans, will be supplied by the contractor.

The portions of the specifications devoted to guarantees and tests are of such interest and importance that we quote them in full, as follows:

> (115) The contractor shall guarantee the following conditions to be fulfilled when the plan is operating without additional fuel at or about its rated capacity and before final payment will be made:
>
> (a) That no nuisance is created in the ordinary operation of the plant.
>
> (b) That no odors, obnoxious gases, smoke or dust escape from the chimney or building.
>
> (c) That at no time during the normal operation of the plant, the temperature in the combustion chamber, due to defects in design or construction and as ascertained from a continuous record, falls below 1,250° F. and that an average temperature of at least 1,500° F. is maintained in the combustion chamber.
>
> (d) That the residual from the furnaces, under the working load of 75 tons per unit per day, is thoroughly burned, hard and free from organic matter.
>
> (e) That the flues, dust collectors, furnaces and combustion chambers are so arranged that it shall not be necessary to shut down any unit for more than 48 hrs. in order to thoroughly remove the dust and ashes.
>
> (f) That the pounds of refuse which will be incinerated per square foot of the grate area upon which final combustion takes place, shall be not less than that stated in his bid for three conditions, namely, for extreme summer refuse, for extreme winter refuse and for an average annual refuse.
>
> (g) That the average rate of evaporation in the boilers, from and at 212° F. per pound of average annual refuse consumed, shall not be less than stated in his bid.
>
> (h) That the average cost per ton for incinerating the average annual refuse in the furnaces which he proposes to build shall not be more than stated in his bid.
>
> The quantities of garbage, household ashes, rubbish and manure upon which these guarantees are based shall accord with the tables given in section 6 of these specifications, and shall be of the following proportions by weight as determined by the engineer and mixed by the contractor, under the direction of the board of public works:

Extreme Summer Refuse.	Extreme Winter Refuse.
57% of garbage.	31% of garbage.
30% of household ashes.	60% of household ashes.
5% of rubbish.	6% of rubbish.
8% of stable manure.	3% of stable manure.
100%	100%

Average Annual Refuse.
41% of garbage.
41% of household ashes.
5% of rubbish.
13% of stable manure.
100%

> (116) In order to demonstrate the sufficiency of the plant to incinerate refuse without the use of additional fuel, in accordance with the specifications and guarantees, three tests shall be made. One test shall be made using extreme summer refuse, one test using extreme winter refuse and one test using average annual refuse. Each of these different grades of refuse is to be proportioned as given in section 115 next above. The sufficiency of the plant to fulfill the specifications and guarantees will be judged from these tests as set forth below.
>
> In addition to these a fourth test shall be made equal in every respect to the other three tests, excepting that the refuse incinerated will consist of garbage, household ashes, rubbish and manure mixed in a proportion to be determined by the engineer, as if all of these ingredients were collected from the entire city and that the fulfillment of the guarantees will not depend in any way upon the result of this fourth test. An evaporation test shall be made with this fourth test.
>
> A different furnace unit shall be used for each of these tests so that each of the four units will be tested once. Each test shall last for five days of eight hours each. The sufficiency of the plant to fulfill guarantees a, b, c, d and e, of section 115, will be judged on all of the five days of each of the three tests. On one of the five days of each of the three tests required, a complete efficiency and evaporation test shall be made and the sufficiency of the plant to fulfill guarantees f and g of section 115 next above will be judged during these tests. The sufficiency of the plant to incinerate refuse at the average cost per ton as stated in the bid and guaranteed under item h of section 115 next above will be judged during the five-day test in which annual average refuse is incinerated and will be determined in the following manner:
>
> The engineer will prepare an accurate statement at the end of the test; first, of the total number of tons incinerated; second, of the number of hours of labor devoted to each operation by each class of workmen; and, third, of the total number of pounds of steam which has been used in connection with all operations from the time the refuse has been dropped into the hoppers until it is deposited as ash and clinker outside of the building not less than 5 ft. nor more than 15 ft. therefrom.
>
> Using the engineer's statement of the quantity of labor and power required to incinerate the total number of tons recorded during the test and the unit prices for labor and power as given below, the engineer will determine the actual cost per ton for incinerating the average annual refuse.
>
> All steam produced will be credited in the test at the rate of 4 cts. per 100 lbs. of steam or 1⅛ cts. per KW.-hr. of electrical energy.
>
> The unit prices of labor and power used in computing the average cost of incineration per ton, to determine whether or not the contractor has fulfilled his guarantees, shall be as follows:

Engineers	$3.00 per day of 8 hours.
Mixers, feeders, stokers and clinkerers	2.00 per day of 8 hours.
Laborers	1.50 per day of 8 hours.
Power, 4 cts. per 100 lbs. of steam or 1⅛ cts. per KW.-hr. of electrical energy.	

> A laborer shall not do any work in the operation of mixing, feeding, stoking or clinkering of the furnaces.
>
> The contractor shall make these tests whenever he so desires, provided, however, that for at least two months the furnaces have been subjected to a slow drying to

avoid cracks in the brick work. For this purpose the contractor shall maintain a small fire with ashes and rubbish delivered by the city. Only one unit shall be tested at a time, and the engineer will determine which unit shall be used for each test.

If the average cost per ton as determined by these tests exceeds by 15% or more the cost guaranteed by the contractor, this fact will be considered as sufficient proof that he has not fulfilled his contract, and shall be cause for rejecting the furnaces, combustion chambers, pre-heaters, forced-draft apparatus, steam boilers, piping, tools and all appurtenances pertaining to these structures, as specified in sections 57 to 69, inclusive, and sections 71, 72, 76 and 77 of item V. of these specifications, and the contractor shall remove the same from the building within 30 days after written notice of such rejection has been given by the board of public works.

If, however, the average cost per ton, as determined by the tests described above, exceeds the guaranteed price by less than 15%, there shall be deducted from the moneys due the contractor, as liquidated damages to the city of Milwaukee, a sum equal to the present worth of a capital representing the cost over and above the guaranteed contract price of incinerating the refuse during the next succeeding three years. To determine this sum definitely the discount rate shall be assumed at 6%, and the total number of tons incinerated during the next succeeding three years at 300,000.

If the retained percentage of moneys due the contractor shall not be sufficient to cover the required deduction determined in this manner, the deficiency shall be made good from the surety bonds deposited with the city to cover the full value of the work.

(117) During these tests all labor required in accordance with a written statement of the contractor shall be supplied by him, but at the expense of the city, at the prices stated in section 116, and the city shall also supply free of charge all refuse, water and light for the tests. The contractor shall furnish at his own expense a competent and experienced man to superintend the tests in conjunction with the engineer, and this superintendent shall not leave the works while the tests are being made, nor until the tests are completed.

(118) In the event of a dispute arising between the contractor and the city about the adequacy and true results of these tests, they shall each appoint a representative, and these two shall appoint a third. These three representatives shall make a sufficient number of further tests to determine the doubtful capabilities of the plant, and their decision as to such capabilities shall be final. The expense of these supplemental tests and of the representatives conducting them shall be paid for jointly by the contractor and the city, each party paying one-half.

(119) If, in the tests, the plant does not come up to requirements, or does not fulfill each and every one of the guarantees or specifications, the city may refuse to accept the plant, in which case the contractor shall remove from the city's property the furnaces, combustion chambers, pre-heaters, forced-draft apparatus, steam boilers, piping, tools and all appurtenances pertaining to these structures. All moneys that have been paid on account to the contractor for these structures shall be deducted by the board of public works from other moneys due the contractor or from the surety company's bond deposited by the contractor at the time of executing the contract. However, every reasonable opportunity shall be given to the contractor to make changes in the incinerator, if by so doing it may be made to satisfactorily fulfill the requirements and guarantees. The contractor shall make these changes at his expense in a thoroughly workmanlike manner, and shall then conduct further tests as described in sections 115 and 116, but at his own expense, to demonstrate to the engineer that the changes made have sufficiently raised the efficiency of the plant. But such demonstration shall not debar either the contractor or the city from demanding a test conducted by three representatives and paid for as specified in section 118.

Four bids were received under the specifications just outlined. These were reported on by Mr. Hering in the form of a table, reprinted herewith. The upper portion of the table is in the nature of an exhibit of the proposals of the various contractors with regard to character of equipment and guaranteed results in the way of unit capacity, cost and revenue. The lower portion of the table gives unit and lump sum prices, and also the data which serve as a basis for determining the lowest bidder. This determination is based on both capital charges (10% of the total price bid) and guaranteed operating expenses. Taking into account the estimated revenue from steam generated by the incinerating plant, the figures submitted by the lowest bidder show that the plant proposed would be operated at a yearly profit of $7,962.

In order to give a clearer idea of the method employed in the final comparison of bids, we make a further quotation from the specifications as follows:

To 10% of the total amount bid for furnishing and erecting the plant, as tabulated by the board of public works, which 10% is assumed to represent the incurred annual fixed charges, will be added the annual operating cost of incineration, estimated by the board of public works to be 100,000 times the guaranteed price bid for incinerating one ton of average annual refuse. This sum shall be the price bid by the [illegible] for the incineration of the refuse according to [illegible] contract. The lowest price thus ascertained the lowest bidder. In the event [illegible] board of public works will determine [illegible] whom the contract will be awarded.

Perhaps it will not be amiss to [illegible] to the fact that under the plan [illegible] bids outlined above and exhibited [illegible] no capital charges are included [illegible] structure of the building to house [illegible] erating plant, nor for the chimney [illegible] this is unnecessary for comparative [illegible] of course these items should be [illegible] count in considering the total cost [illegible] disposal.

Another item common to any of [illegible] and which has been included in the [illegible] estimated yearly cost of weighing [illegible] its receipt at the plant, hoisting [illegible] mitting it to and dumping it into [illegible] This is estimated at $15,000, and [illegible] that amount the net profit of nearly $[illegible],000, computed on the basis of the figures submitted by the lowest bidder.

The Proposed Addition to the New York State Barge Canal by Enlarging the Cayuga and Seneca Canal.

On Feb. 4, 1909, the Senate of the State of New York passed a resolution, requesting that it be furnished with "such information and such specific data as can be provided * * * bearing upon the probable cost of construction" and other features relating to the suggested improvement of the Cayuga and Seneca lake outlets, which will convert these lakes and their outlets into a part of the Barge Canal system now in course of construction in New York State. These two lakes, the largest of that group in central New York, known as the "Finger lakes," are in a country capable of large development. At present the lakes themselves are navigable for good sized craft, though harbors, breakwaters, etc., are needed. The rivers flowing out of the lakes, however, were improved for navigation at a very early day, when the canal boats in use were very small, and complete reconstruction would

TABULATION OF BIDS FOR PROPOSED REFUSE INCINERATION PLANT, MILWAUKEE, WIS., MARCH 31, 1909.

Items.	Universal Destructor Co., New York.	Macdonald Engineering Co. Chicago, Ill.	Lewis & Kitchen, Chicago, Ill.	Power Specialty Co., New York.
Drawings submitted	All drawings submitted were satisfactory.			
Refuse incinerators referred to as furnishing evidence of successful operation and of ability to do the work*	A certificate signed by the city engineer, showing the satisfactory operation of the Seattle incinerator.	A certified report of the test of the Horsfall incinerator at Greenock, Scotland.	Submits public document containing data and monthly report of Seattle incinerator. Also submits two signed endorsements of crematory at Fort Leavenworth, Kan.	Published and certified report with letters showing successful operation and proper connection with West New Brighton, N. Y., incinerator.
Forced draft apparatus proposed	Steam jet.	Steam jet and fan engines.	Steam jet and fan engines.	Steam jet and fan engines.
Guaranteed rate of burning per sq. ft. grate area, per hour	Extreme summer....52.1 lbs. Extreme winter.....65.1 lbs. Average annual.....57.3 lbs.	70 lbs. 90 lbs. 80 lbs.	39 lbs. 39 lbs. 39 lbs.	60 lbs. 60 lbs. 60 lbs.
Guaranteed evaporation per pound of refuse for average annual refuse	1.0 lb.	0.75-lb.	1.45 lbs.	1.1 lbs.
Pounds of steam per hour to operate the plant	6,480 lbs.	3,600 lbs.	5,500 lbs.	3,200 lbs.
Possibility of fulfilling guarantee	Satisfactory.	Satisfactory and conservative	Doubtful.	Satisfactory.
Revenue value of steam per ton, as guaranteed by bidder, according to specifications from and at 212° F.	80 cts. per ton.	60 cts. per ton.	98½ cts. per ton; corrected by Board of Public Works to be $1.16 per ton.	88 cts. per ton.
Bidders statement of guaranteed cost of labor and power required to operate plant within specified limits	73 cts. per ton.	43 cts. per ton. (Changed by the Board of Public Works, because labor on cranes is wrongly included and power omitted.)	80½ cts. per ton; corrected by Board of Public Works to be 84.68 cts. per ton.	47 6-10 cts. per ton.
Net revenue per ton of incineration as bid and as computed by Board of Public Works from bidders' guaranteed statements	7 cts. per ton.	17 cts. per ton.	Bid: 11 cts. per ton. Computed: 31½ cts. per ton.	40 4-10 cts. per ton.
Item. Quantity.				
Excavation 2,500 cu. yds.	65 cts.—$1,625.00	$1.25—$3,125.00	55 cts.—$1,375.00	52½ cts.—$1,312.50
Piling, per lin. ft. 40,500 lin. ft.	30 cts.—12,150.00	40 cts.—16,200.00	24½ cts.— 9,922.50	24 15-100 cts.— 9,780.75
Concrete, per cu. yd. 900 cu. yds.	$8.00— 7,200.00	$8.00— 7,200.00	$6.85— 6,165.00	$6.04— 5,436.00
Steel reinforcement, per lb. 5,000 lbs.	3 cts.— 150.00	3½ cts.— 165.00	2¼ cts.— 112.50	2½ cts.— 125.00
Furnaces, combustion chambers, etc. lump sum	117,700.00	100,000.00	118,650.00	132,267.00
Storage hoppers, floors, etc., lump sum	22,030.87	14,280.00	26,726.00	15,900.00
Cranes, generators, scales, etc., lump sum	14,131.26	9,812.00	12,420.00	9,500.00
Total amount of bid for constructing and erecting the refuse incineration plant	$174,987.13	$150,782.00	$175,371.00	$174,384.25
10% of total amount for constructing and erecting the refuse incineration plant	17,498.71	15,078.20	17,537.10	17,438.00
100,000 × the net revenue per ton, for incineration, as computed by the Board of Public Works, from bidders' guaranteed statements	7,000.00	17,000.00	Bid—11,000.00 Computed—31,333.33	40,400.00
Net cost or profit per annum to incinerate 100,000 tons of refuse as specified	Cost—$10,498.71	Profit—$1,921.80	Cost bid—$6,537.10 Profit computed—13,796.23	Profit—$22,961.58
Additional estimated cost per annum of handling refuse at works, weighing, hoisting, dumping, etc.	15,000.00	15,000.00	15,000.00	15,000.00
Final estimated cost or profit per annum, assuming that all steam is utilized and returns; 4 cts. per 100 lbs. from and at 212° F.	Total cost—$25,498.71	Total cost—$13,078.20	Total cost: Bid—$21,537.10 Computed— 1,203.77	Total profit—$7,961.58

*Note: The furnaces referred to under the second item as being in successful use are (1) Meldrum, (2) Horsfall, (3) Meldrum and design of bidder, and (4) Heenan & Froude—the latter being the accepted design.

The contract for the proposed radial brick chimney, 131½ ft. high above the foundation and 10 ft. internal diameter at the top, was awarded to the M. W. Kellogg Co., of Chicago, at its bid of $4,485 for buff brick.

be necessary to admit such craft as will use the barge canal. The estimated cost of this improvement is about $6,000,000.

The following is condensed from the report of Mr. F. C. Stevens, Superintendent of Public Works, upon this project:

The principal use of the Barge Canal, it has well been said, is not the distribution of merchandise and the ordinary trade of cities, but in the transportation of bulky commodities transported and delivered in bulk—such as salt, cement, gypsum, coal and grain. Nowhere else are there to be found such deposits of salt, gypsum and other like commodities, as are to be found on the shores of Cayuga and Seneca lakes. The industry of mining, manufacturing and disposing of such commodities in this region may be said to be in its infancy still; yet even now the shipments from those points are enormous.

It is a fact, easily capable of proof, that there is no territory contiguous to the Barge Canal, of the same extent, that will furnish anything like the amount of traffic which ultimately will be furnished from the territory of the Cayuga and Seneca lakes, for, entirely aside from the products of the farm, vineyard, mines and mills, it should not be overlooked that with the suggested improvement the harbors at the upper ends of both Cayuga and Seneca lakes, already connected with the coal fields by rail, will be the nearest points to the center of the coal fields it will be possible to reach for water shipments.

The suggested improvement is entirely feasible and from every standpoint desirable, and it will not involve unusual engineering difficulties; but the improvement can be accomplished at an expenditure of a sum under six million dollars. Access has been had to the material and data gathered by actual survey by the former State Engineer and Surveyor, Henry A. Van Alstyne, so far as the improvement of the Cayuga Lake outlet is concerned, and in addition there has been available much data resulting from personal observation during the last three years of those having to do with the enlargement of the canals, so that the conclusions herein presented so far as they relate to that portion of the suggested enterprise, may be accepted as within the realm of certainty.

As to the improvement of the outlet of Seneca Lake, while there has not been either time or opportunity to make detailed surveys on which to base an estimate of quantities, nor detailed tests necessary to determine absolutely and finally as to the character of material to be encountered, there has been as careful examination made of the territory through which the improvement would pass as time has permitted, and the observations thus made, taken in conjunction with the knowledge which those who did the observing have of the territory, the geological formation, general contours and topographic characteristics, combined with the knowledge and experience which have come from actual participation in larger and more important engineering enterprises, as well as actual demonstrations arising from the Barge Canal work, render the conclusions dependable.

An attempt has been made to take into consideration every possible contingency. There is no physical condition to be met with and no engineering feature or obstacle foreseen in connection with this suggested improvement, which has not already been met with and passed upon in connection with Barge Canal work, either actually in progress or under contract to be performed: If the actual prices at which similar work is not under contract to be performed, were applied in making computations, the estimate herewith presented would be even lower than it is. But recognizing that to make use of minimum prices already secured would be dangerous and might be misleading, in every case maximum contract prices have been adopted for purposes of computation, and on top of this, contingencies are provided for which are only remotely possible and not at all probable.

The detailed estimate presented below has been made by Mr. Joseph Ripley, advisory engineer in this department, and has been checked and confirmed by another engineer of no less eminence, experience and reliability. The following detailed estimate, therefore, is reliable in all of its features; it can be defended as conservative and can be relied upon.

The following estimates of cost of construction are for a canal 75 ft. bottom width, with a slope of 1 on 2 in earth, with a dimension of 94 ft. width and upwards at points where rock would be encountered, and where vertical walls should be provided, with a depth of 12 ft. channel and of standard size Barge Canal locks.

The alinement of the canal from Cayuga Lake outlet to Seneca Lake, would approximately follow the present Seneca Canal, though deflections can be easily made where desirable to secure better alinement, or to profit by topographical features. Such divergencies would minimize the interference with navigation of the present canal during the construction period.

It is possible, however, that a careful survey would result in determining that as an outlet from Seneca Lake to the Barge Canal proper, a different route should be followed.

CAYUGA CANAL.

Estimate of cost for 75 ft. canal from Barge Canal at Montezuma to deep water in lake:

Clearing	$800
All excavation	442,740
Lock	226,700
Concrete walls, building and dreining	119,840
Bridges	58,650
Regulating works	100,000
Right of way	10,050
	$958,780
Add 15% for engineering and contingencies	143,817
Cayuga Canal	$1,102,597

SENECA CANAL.

Clearing	$10,000
All excavation	2,100,000
Wash wall	75,000
Locks	900,000
Dams, weirs and culverts	100,000
Bridges	300,000
Guard gate	30,000
Break-water, piers and dredging	100,000
Bailing and draining	110,000
Right of way	350,000
Maintaining navigation	20,000
Miscellaneous	100,000
	$4,255,000
Add 15% for engineering and contingencies	638,250
Seneca Canal	$4,893,250
Cayuga Canal	1,102,597
Total	$5,995,847

As to the construction period, there is little doubt but that final completion could be effected in five years after detailed plans were perfected. And if in connection with the surveys which would have to be made before detailed plans could be prepared, in the event the improvement were authorized, the detailed plans of the most difficult portions were given precedence, there is likelihood that the construction period could be reduced materially. The instrumental surveys and the plans for the most difficult sections, from a construction standpoint, could be completed within a year's time.

I understand it is the judgment of the State Engineer and Surveyor that the detailed surveys and the detailed plans for the most difficult sections, namely, at Seneca Falls and Waterloo, can be made for about $40,000; and I join the State Engineer and Surveyor in urging the immediate appropriation of an adequate sum and the authorization of detailed surveys, including such engineering inquiry as shall determine whether the river route or one of the divergent routes, as an outlet from Seneca Lake, should be finally selected.

Summed up, with an expenditure of six million dollars, there will be added to the Barge Canal system in round numbers 100 miles of waterway, 80 miles of which are natural deep waterways; the percentage of cost, based on the total mileage added, in comparison with the total cost of the Barge Canal proper, based on mileage, being infinitesimal.

The Problem of Reducing Smoke on Railroads.*

By ALFRED W. GIBBS.†

Comparisons are continually being made between the railroads of this country and those of foreign lands, and these comparisons, while admitting certain great accomplishments performed by our roads, also dwell on our shortcomings, and in no direction more vigorously than as regards the emission of smoke. The query which continually arises is: Why, when the railroads have accomplished so much in other directions, have we today an equal or greater amount of smoke than we had many years ago? Is it because the railroads are supine in this matter? Or, is it because the problem is one not capable of solution?

The railroads are not supine in this matter. They are officered and manned by good citizens whose interest is really that of the rest of the community; usually, they live along the line of the road with which they are connected; the smoke that annoys others, vexes them to an equal or greater extent; and aside from their duty as citizens, is the strong motive of self-interest to escape annoyance for reasons of personal comfort.

SOME GOVERNING FACTORS.—With the railroads of this country the prime essential in manufacturing cheap transportation is the possibility of hauling large train units. In this, we differ radically from the railroads of other countries, with which comparisons are most frequently made; that is to say, more frequent and lighter units are the rule.

This means that in this country the locomotive has developed into a power plant of the most concentrated character, for instance: Where with a stationary plant we are satisfied to burn from 15 to 25 lbs. of coal per square foot of grate surface per hour, in many of our locomotives we must be able to burn not less than 100 lbs. of coal per square foot of grate surface within the same period of time. In a stationary plant, fluctuations in the demands are comparatively slight and can usually be anticipated and prepared for in advance, while with the locomotive, on the other hand, we must be able to vary the output enormously within an extremely short period of time.

A locomotive may be working at full power, producing little smoke, and be suddenly forced to shut off or stop, under which condition the fire will not adapt itself immediately to the changed requirements, and even with care, under such circumstances, the emission of smoke is certain. The reason for this is that while working with forced draft, there is a fair balance between the rate at which the coal is consumed and the air drawn over the fire to complete the combustion, and the volatile material is distilling off at a fairly uniform rate. With the cessation of the draft, but with the coal still emitting quantities of volatile gases, air is not drawn in in sufficient quantity, with the result so frequently experienced.

Again, many coals which when burned in a leisurely manner give little of no visible smoke, will give great annoyance when the rate of combustion is doubled or trebled as the case may be. Consequently, it may reasonably be expected that the terminals in level country, where trains can be handled in and out of the station without excessive demands on the locomotive, are likely to be more nearly smokeless than those where the locomotive must be overworked from the start.

LIMITATIONS OF SIZE.—Limitations of space, such as width of gage, tunnels, bridges and other clearances, restrict us in the possible dimensions of the locomotive power plant; consequently, the whole plant—particularly the boiler—is operated at an intensity nowhere else required. This is the crux of the whole situation, for while it is possible to burn almost any fuel smokelessly, provided the operation be not too hurried, it requires considerable skill and the best appliances to do so when the rate of combustion is forced to the utmost.

The question may now very properly be asked, how do the conditions of the present day differ from those of the past, and why is this question of smoke prevention more important now than ever before?

In answer to this it may be stated: First, that while the design of the locomotive in its essential details, differs but slightly from the older types, there has been a great increase in the number and size of the locomotives and in the demands made on them. Secondly, it is to be noted that the complaints against smoke usually come from cities and towns, rather than from the country. This is natural, for the reason that there are more people and more locomotives at the terminal, and it is just there that conditions are naturally the worst, for it is at the terminals where old fires must be cleaned and new ones started. It is then, of all times, that smoke is most unavoidable. It is also true that many railroads have built their terminals in what was then the country, but cities have grown up around them, and with the growth come the complaints. The public demands facilities in the heart of business centers, in order to cheapen drayage and afford convenient access for travelers.

METHODS OF SOLVING PROBLEM.—The means which the railroad has at its command for the elimination of smoke, are:

First.—The use of comparatively smokeless fuel;

Second.—The use of devices of various kinds which may allow the use of otherwise smoky fuels; and

Third.—The education of the men operating locomotives and supervising their work.

FUEL AVAILABLE.—It is evident that the railroads must produce power with the fuel of the country through which they run, and a glance at a geological map of this country, will convince any one that bituminous coal is that with which this question must be settled. Anthracite is confined to practically a few counties in the Eastern part of Pennsylvania. The amount of anthracite mined is a trifle more than 70,000,000 tons each year. It is the ideal fuel for domestic purposes and for use in plants where its cost is not prohibitive. The total amount is so limited, however, that were the demand to be on this fuel alone, the supply would be inadequate.

Some of the anthracite roads use considerable amounts of bituminous coal. In many cases this bituminous coal is used as an admixture in order to make it possible to burn under locomotive conditions, the very small sizes of anthracite otherwise not available. This mixture of two coals is not smokeless. If many railways were to adopt anthracite for locomotive use it would but hasten the disappearance of this most valuable fuel, to say nothing of the enhancement in price which would most assuredly follow and directly affect every householder now dependent on this fuel. Granting that the anthracite thus absorbed by the railroads were replaced by bituminous coal for domestic purposes, the smoke situation would be far worse than at present because the numerous small domestic fires, with the usually imperfect combustion, produce more total smoke than would the same amount of bituminous coal burned in locomotive furnaces. The item of cost to the railroads would be such a tremendous increase in their expenses as to make it absolutely prohibitive. A recent study of this subject

*From a paper prepared at the request of the American Civic Federation.

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showed that on nineteen of the principal roads, the fuel bill exceeded 11.4% of the total operating expenses, or nearly 8% of the gross earnings.

COKE.—The total production of coke is 36,000,000 tons annually, which is almost entirely used in metallurgical work, for which there is no substitute. While it may be admitted that the production of coke could be largely increased, it should be remembered that in the production of coke from bituminous coal, there is an initial waste of about one-third of the heating value of the fuel, with further losses from breakage in handling, it is evident that this attempted solution would be an unpardonable waste of our natural resources.

However, in the endeavor to obviate smoke, a great many attempts have been made to use coke, and the records of the tests show that the results have been very unsatisfactory, owing to the difficulty with which the fuel is handled, at times the heat being entirely too intense and at others the fire being almost stopped up by the ashes produced. It must not be forgotten that in the process of burning coal to coke, the ash originally in the coal remains in the coke, so that in burning a ton of coke, much more ash results than from the consumption of a ton of the coal from which it was made. The coke, when used, is satisfactory in but one particular, its freedom from smoke.

BITUMINOUS COAL.—Of bituminous coal, somewhat over 400,000,000 tons are mined annually, and the total consumption of this fuel by the railroads of this country is estimated to closely approximate 100,000,000 tons. This railroad consumption, it will be noticed, is almost sufficient to exhaust the present total production of both anthracite and coke, so that we may as well admit that, this being a bituminous coal country, it is this fuel alone that we must consider in solving this smoke problem, although possibly in certain restricted localities we may be justified in entirely disregarding all questions of expense and using only smokeless fuel; this for the sole purpose of controlling the smoke.

CHEMISTRY OF BITUMINOUS COALS.—The composition of our various bituminous coals differs widely. Some of them are relatively smokeless. Chemically, these are characterized by the great amount of fixed carbon and the small amount of volatile or flame-and-smoke producing constituents. Approximately, these may range from 70 to 80% fixed carbon, from 15 to 22% volatile matter, the remainder being moisture, ash and sulphur. On the other hand, some of the highly bituminous coals will contain less than 50% fixed carbon, and over 40% volatile material, and it is with such wide variations in composition that the question must be settled.

It is customary to group under the head of "volatile material," all the substances which will distill from the coal when heated in a closed tube, but on examination it is found that the composition of this material is quite complex, and it does not follow at all that the volatile material of one coal differs only in amount from that of another grade. While much has yet to be learned of the ultimate composition of this material, it is safe to say that some coals contain more of the smoke or soot-producing constituents than others. In other words, some bituminous coals while containing approximately the same percentage of volatile material, are more difficult to burn without the emission of smoke.

The low-volatile bituminous coals have, unfortunately, the peculiarity that they are extremely friable and even though mined in lumpy form, will very speedily break up into small size. Although this does not interfere with their usefulness where burned slowly, it is a very serious hindrance to their use in locomotive boilers when worked to the fullest capacity, for the reason that the powerful draft throws out of the chimney a very large part of the fuel put into the firebox, and while at low rates of combustion these are the most efficient of our bituminous coals, this condition does not hold true when the demands on the locomotive are increased. For locomotive purposes, the physical structure of the coal is actually more important than the chemical composition. The important requirements are that the coal shall be fairly lumpy; that it shall be fairly uniform in size; that it shall not readily break up in the atmosphere; and that it shall retain its form in the firebox. When these conditions are met, such fuel can be burned with comparatively little smoke, owing to the possibility of maintaining a thin bright fire.

BRIQUETTES.—A possibility of the future, not yet fully developed, is the use of smokeless or low-volatile coals made into briquettes by the addition of suitable binding material, after which the fuel is pressed into large blocks. This practice, long known and utilized abroad, is now being developed in this country, very intelligent work being done by the United States Geological Survey, and while at present the cost of fuel so produced is so high as to be prohibitive, it is hoped that this method of preparing fuel may ultimately prove a factor in relieving the smoke nuisance. The conservation of our natural resources makes it imperative that we should be able to utilize all sizes and kinds of coal, so that instead of selecting the best of the coal and leaving the inferior grades in the mine, the vein which is being mined should have all the fuel removed, as otherwise the settling of the ground causes the total loss of all the unmined fuel. To the extent that briquetting helps to attain this result, its extension is desirable.

OIL FUEL.—Oil fuel is largely used in some parts of the southwest, where there are great deposits of oil, otherwise of little value. Owing to the distance and the difficulties of transportation, it is not likely that this fuel can be considered as one available for railroads other than those in the territory where such oil abounds, and it may be dismissed from our consideration.

To recapitulate: Anthracite, coke and low-volatile bituminous coal are all being used, to a greater or lesser extent, at various points where the smoke condition is most pronounced, in order to minimize the annoyance, but, as has been pointed out, the extension of the use of such fuels is distinctly limited, and the great question remains: By what appliances or methods, without annoyance to the community, shall we successfully burn the bituminous coal which must be our reliance?

REQUIREMENTS FOR SMOKELESS COMBUSTION.—There is probably no railroad of importance which has not from time to time introduced appliances for this purpose. The basis on which such devices are planned is as follows:

First.—To distill the volatile gases at as uniform a rate as possible.

Second.—To present to the burning gases an adequate supply of air to effect complete combustion.

Third.—To thoroughly mix this air with the gases.

Fourth.—To effect this mixture while the gases are still at a very high temperature.

Fifth.—To allow sufficient time for this mixture and combustion of the air and gases to take place before the heat is absorbed and the temperature reduced below the combustion point.

With these five conditions complied with, the whole difficulty is overcome, and just insofar as the devices meet these five conditions are they successful.

DEVICES.—A bare mention of all these devices would be tedious, but it may not be amiss to indicate some of the methods by which this has been attempted.

The first condition is the manual one of introducing the coal steadily and in small quantities, preferably allowing it to coke near the door.

The brick arch placed across the lower forward end of the firebox and inclined upward and towards the rear, acts as a baffle to increase the distance that the burning gases must flow before the cooling of the flame is effected. In this process, the arch becomes intensely hot, thus maintaining the high temperature while the firedoor is momentarily opened. This device partly meets conditions 4 and 5 and when supplemented by judicious air admissions above the fire, partly meets the last four conditions. This, one of the oldest devices, is probably the best and was once the general standard for locomotives of the Pennsylvania and other railroads. The reason why it was not maintained is that its presence in the firebox is a very serious obstacle to the proper and frequent inspection of the interior, on the perfection of which examination safety hinges. The arch remains incandescent for a long period, thus making proper inspection impracticable. The other reason for its disuse is that the locomotive is a power plant of such concentrated character and so highly forced that the arch alone without very intelligent firing, will not prevent smoke. To illustrate, it is perfectly practicable to operate at moderate power with such an absence of smoke that for periods of more than one-half hour not a particle of smoke will be visible, but let the conditions change, now shutting off, now working to the utmost limit of capacity, and smoke at once appears because the device will not adapt itself to these extreme conditions.

Other devices embody one or more of the following: Air pipes through the sides of the firebox to admit air to meet conditions 2 and 3; this is only partially effective. Again, air pipes more or less exposed to the heat of the fire so as to preheat the air, are tried, thus attempting to meet conditions 2, 3 and 4. The difficulty with this type is that the heat of the fire usually destroys the device. Still others employ steam jets, sometimes superheated, to thoroughly mix the gases and comply with conditions 2 and 3. Then there is the constantly recurring attempt to bring back to the firebox some of the smokebox gases, as well as the partly burned cinders there collected. This has never been developed to an extent to afford any promise.

AUTOMATIC STOKERS.—In this connection, while considering devices, we cannot omit all reference to the question of automatic stokers. The general progress demands transferring the burden of great manual exertion from the man to a machine, the latter doing the hard work and the man supervising the action of the machine. With this end in view, a great deal has been and is being done in the direction of developing automatic stokers which will do the firing with a certain amount of manual supervision. Of these devices, quite a number have been devised and put into use on locomotives. So far, they have not proven satisfactory and, from their imperfections, have not improved the smoke conditions, but the demand for them is so urgently recognized by the railroads, not only from the mere smoke question, but also on account of the saving in money and relief to labor that there is ground for hope that in the comparatively near future, a satisfactory automatic [illegible]er will be developed. The problem is a most [illegible]lt one, and at present some of the brightest and [illegible]practical minds are at work on a solution, and although [illegible]t is difficult to predict how soon success may be att[illegible], it is certain that decided progress is being effecte[illegible]

The automatic stoker, when perfect[illegible] promises to be one of the most effective appliances [illegible]d in the suppression of smoke, for the reason that [illegible]oes not become tired from the hard work and, conse[illegible]ly, should do as well after hours of service as in [illegible]beginning; the contrary is the case with the man. F[illegible]is reason, the stoker, when perfected, will come to s[illegible]

The gist of the matter is that devices [illegible]e, unless supplemented by intelligent and unremitting [illegible]ttention, never long survive. They start with a flare [illegible]trumpets; they show a decided improvement over pr[illegible]ous conditions; then less is heard of them; and, finall[illegible] when inquiry is made, it is found that they have been removed as inefficient. The real reason is, that wh[illegible] new they received a degree of attention that make[illegible] them more or less successful, and the credit is ascribed largely to the device when it is actually due to the care.

Evidently, the real line of progress is to stimulate and maintain the intelligent care, and it is in the latter direction that the most progress is being made, and where there is the greatest hope for the future.

SUPERVISION.—Let us now consider what we believe to be the ultimate solution of the problem, without which the best fuel, and the best appliances, will not be effective in reducing smoke, namely the education and supervision of the men running and firing locomotives.

It must be remembered that on a large railroad system, there are thousands of men firing and handling locomotives. First, we have the engineman, who runs the machine and upon whose careful and judicious handling the ease of proper firing largely depends; secondly, we have the fireman, whose skill and interest in properly firing the locomotive must never flag for an instant; third, we have engine-preparers and ashpitmen at engine-houses, who must understand how to clean old fires and build new ones with a minimum amount of smoke.

With the rapid growth of business and consequent increase in the number of employees, it must be realized that supervision in this sense requires a large force of men, for the reason that owing to the extent of the territory over which any group of locomotives and men run, following up any particular set of men is a very different proposition from that of supervising a very much greater number of men grouped in some one place, as, for instance, in a large power-house.

The supervision to be effective involves, first, accurate instruction, and, secondly, repeated personal visitation to see whether this is followed, and, third, discipline if the instruction is persistently disregarded, either from inability or indifference, and the correction of abuses, such as the improper preparation of the locomotive for the run.

To show how this supervision is being effected, it must be understood that the organization of the railroad is practically a military one. On each division, the man in charge of the enginemen and firemen, under the superintendent, is the road foreman of engines, who has assistants, each in charge of districts containing a certain number of locomotives and men. In some cases it is the practice for these assistants to have subordinates to instruct in firing, although the tendency is to put in this position, men taken from the ranks of the enginemen, so that their rank will carry authority to instruct both enginemen and firemen. In addition, smoke inspectors, whose entire duty is to report locomotives emitting black smoke, are stationed at various points along the division.

PRINTED INSTRUCTIONS.—The management has prepared definite and uniform instructions, in printed form, which have been placed in the hands of all men responsible for operating, firing and attending to locomotives on the road and at terminals. From these instructions we quote the following which pertain particularly to the elimination of smoke, namely:

"Enginemen and firemen must work together so as to save coal and reduce smoke."

"The burning of bituminous coal in a locomotive requires air, which must be admitted through the grates and through the fire-door."

"Smoke means waste of coal and must be avoided."

"Large quantities of coal placed in the firebox at one time cool down the fire, cause smoke and waste coal; small quantities at regular intervals will keep the fire bright, prevent smoke and take less coal to keep up steam pressure."

"Lumps of coal should be broken in pieces not larger than 3 inches."

"A bright and level fire over the whole grate must be carried wherever possible. When a sloping fire is used, no more coal should be banked at the door than is necessary."

"To prevent smoke and to save coal, the fire-door must be placed on or against the latch after firing coal or using the scraper, slash-bar or hook, and when on siding, in yards, at terminals, or before starting."

"Before the throttle is closed, the blower must be used and the door placed on the latch. Firemen must stop firing long enough before steam is shut off to prevent smoke and waste of coal."

Under present day conditions, more supervision is required than formerly, on account of the rapid increase in railway business, necessitating the employment and promotion of men who have not been through the long

course of probation formerly the rule. Furthermore, the importance of educating and developing intelligent supervising officers in order to reach the men, is of late being recognized.

At Altoona there has been installed a testing plant consisting of a locomotive whose driving wheels rest on suitable supporting wheel placed beneath and taking the place of the usual track, the whole locomotive being firmly connected to a dynamometer that maintains it in position while recording the work performed by the locomotive, so that it is operated in the usual way and produces the usual pull. It is otherwise stationary, subject to careful inspection and test entirely impracticable with the same locomotive running free on the road. By means of this plant, which is entirely devoted to the purpose of securing information, this road is educating its officers interested in the fuel question to its possibilities, so that they may thoroughly understand how to instruct the men to carry out the definite printed instructions.

Furthermore, this road is recognizing the necessity for greater supervision by the appointment of a greater number of supervising officers so that the number of men under the jurisdiction of each will be small enough to admit of constant personal contact.

It must not be forgotten in this connection, that the cost of the supervision mentioned in the foregoing, is a very serious burden on the cost of operation, and while the railroads would not provide such supervision but for the belief that it will yield adequate return, or from realization of the duties which the railroads owe the public, there must be a limit to the amount of money which they can so expend.

As stated before, the cost of fuel is from 8 to 11% of the total operating cost of a railroad, and, therefore, economy in the consumption of fuel is one of the most obvious ways of reducing operating expenses. Fortunately, the methods described in the foregoing for the elimination of smoke from locomotives, are also those which must be followed in order to obtain the maximum economy in locomotive fuel consumption; in other words, the crew making the least smoke is also apt to save the most coal. It follows, therefore, that the railroads have a direct financial interest in the elimination of smoke to the lowest possible limit.

It should be clearly understood that there is no one remedy which can be generally applied. Each situation must be treated as a separate problem, giving attention to such points as the character of the road as to grades, the loading and speed of the trains, the distance which must be run through thickly populated districts, and whether we are considering a terminal or a through station. For instance, the remedy which has so improved the Washington situation will not apply to Baltimore, because the latter is a through station having adverse tunnel grades on each side. The Chicago situation, with Illinois coal, is still another problem. In brief, an intelligent study of the local conditions must be made in each case.

ELECTRIC OPERATION.—It will be noted that so far, nothing has been said of the possible solution by electrification. This company, as you know, is now engaged in the development of terminals in the neighborhood of New York City, where electric traction is the only thing to be considered, owing to the use of deep subaqueous tunnels. This company is also operating, in the State of New Jersey, a fairly long line on which multiple-unit electric trains are operated.

In the New York installation, we are confronted by the problem of both multiple-unit electric trains and of through trains hauled by electric locomotives. It is but fair to say that while the multiple-unit train seems to be fairly well worked out, the problem of the electric locomotive is far from a satisfactory solution, and although unremitting attention has been given to the subject for years past, it still remains in the experimental stage.

The cost of everything electric is tremendous. The electric locomotives, such as they are, cost more than double the steam locomotives that they replace, and with this but a small part of the story has been told, as we must add the cost of track preparation, of the power plants, and all that goes to make the electric system as a whole.

The demand has frequently been made that if not the entire cross country line, the cities or terminals should be electrified. In some cases the same demand has been made where cities are not terminals for any but a small proportion of the trains running into them. Such a demand would involve two locomotive terminals, one on each side of the city, electrification of the space within the city limits, a supply of special electric locomotives and the delay of a double stop, to say nothing of the difficulties due to the interruption of such functions as the steam heating of trains. To offset the cost of this, there is no saving whatever in operation; on the contrary, the operating cost is largely increased. If the railroads could stand the burden or cost, it is certain that the public itself would not tolerate unnecessary delays of this kind. Naturally, the roads hesitate to undertake new electrifications, not only on account of the expense, but also because it is wise to learn the lesson of the mistakes of one installation and thus avoid their repetition at another.

While anything of the kind is possible with an unlimited expenditure of money, we do not hesitate to say that the time has not yet come when the enormous outlay of capital for the purpose of the electrification of the railroads would be justified by the returns, and, further, we assert that the capital thus diverted would be far more useful in other directions.

Comparative Tests of Large and Small Hammer Rock-Drills.

By J. B. LIPPINCOTT,* M. Am. Soc. C. E.

The tunnel work of the Los Angeles Aqueduct† is mostly done with No. 9 Leyner hammer drills. Smaller drills, No. 7, of the same type have been used to some extent, however, and their use is increasing. Two comparative tests were made recently to determine the relative drilling speeds of the two sizes under identical conditions. The tests were under the immediate direction of Mr. G. C. Ripley, tunnel superintendent, and were witnessed by the writer. In view of the results stated below, it is thought that for work in medium hard rock the small drill might advantageously be substituted for the large one.

Both drills are of the hammer type, i. e., the drill steel is held against the bottom of the hole by the air pressure and struck a blow by a vibrating hammer. The hammer of the large drill has a stroke of 3½ ins., weighs 15½ lbs. and strikes about 600 blows per minute. The hammer of the small drill has a stroke of 5½ ins., weighs 7 lbs. and strikes about 1,600 blows per minute. Both drills were taken off the tunnel work, and had been in service over three months.

The first test was at the south heading of Tunnel No. 35, in Sun Canyon. The rock was a medium granite, which cut nicely and which was hard enough not to ravel. The air pressure at the compressors was 95 lbs., and at the drills probably about 90 lbs. Both drills were set up on the same horizontal bar. One of the machine men working at the heading was selected to run first the large drill and then the small one. In both instances, horizontal holes were driven straight into the face. The drills used steel with the following sized bits:

	No. 9 drill.	No. 7 drill.
1st steel	2⅝-in.	1⅝-in.
2d steel	2¼-in.	1 9/16-in.
3d steel	2-in.	1 7/16-in.
4th steel	1⅞-in.	
Total depth	6 ft. 7 ins.	6 ft. 11½ ins.

*Assistant Chief Engineer, Los Angeles Aqueduct, Central Bldg., Los Angeles, Cal.

†On this work the best previous American performance in rock tunnel driving was twice exceeded, last October with a heading advance of 466 ft. in one month and in March, 1909, with an advance of 476 ft., for one heading. This last record-breaking performance was noted in our last issue, April 15, 1909, p. 421.—Ed.

The large drill had a normal lead of 24 ins. and the small drill of 30 ins. The small drill, therefore, had fewer changes of steel for the same depth of hole, which is to its advantage in this case and would be in other cases, provided the rock was not so hard as to dull the steel unduly for a 30-in. run.

Both sets of steel were sharpened by the same smith, with a Leyner drill sharpener, so they probably were of equal density and hardness. The steel of the large drill, however, was four-point steel, while that of the small drill was five-point. This steel is of the hollow type, with a ¼-in. hole through the entire length through which a water jet is discharged at the same pressure as the air which is furnished to run the drill. The five-point steel cuts the rock finer than the four-point, and the water more freely flushes the fine cuttings from the hole. This is of especial advantage in the softer rocks.

The second test was made in Tunnel No. 37, at the North Heading. This is the hardest rock in this section, being a bluish live granite. This test was made under similar working conditions as the first, except that the sizes of steel were somewhat different.

Both tests are summarized in the table below. From this it will be seen that in the medium granite of Test 1 the small drill worked faster than the large drill by 23%, including time for changing steel, and 14% if only the time required exclusively for drilling is counted.

In Test 2, with hard rock, the small drill exceeded the large one by 53%, including all time consumed and averaging the two runs.

In view of the more rapid work of the smaller drill in both tests, its advantages may be stated as follows:

1. In these classes of ground, more rapid drilling and changing.
2. Lightness of drill and of steel, the small drill weighing 113 lbs. against 245 lbs. for the large drill. The drill steel of the small drill weighs about ½ that of the large drill.
3. The small holes do not ravel and stick the steel as much as the large holes.
4. The small drill is said to consume but ⅔ of the amount of air that the large drill requires, but this was not tested.
5. The small drill costs $150, and the large one $180.

It will be noted that the large drill bored the larger hole by 7/16-in. at the bottom. In hard rock, requiring heavy blasting, larger holes are required in order to hold larger charges of powder. This could in part be compensated by using stronger powder in the smaller holes.

COMPARATIVE DRILLING TESTS OF NO. 9 AND NO. 7 LEYNER HAMMER DRILLS, LOS ANGELES AQUEDUCT.

FIRST TEST.—Tunnel No. 35. Medium Rock.

Large Drill, No. 9.

Diam., ins.	Started.	Stopped.	Time changing.
2⅝	0	2-30	30 sec.
2¼	3-0	4-30	45 sec.
2	5-15	6-45	45 sec.
1⅞	7-30	9-0	.....

Total depth of hole, 6 ft. 7 ins.
Total time, incl. changing steels, 9 mins., = 0.75 ft. per min.
Total time, excl. changing steels, 7 mins., = 0.94 ft. per min.

Small Drill, No. 7.

Diam., ins.	Started.	Stopped.	Time changing.
1⅝	0	3-10	35 sec.
1 9/16	3-45	5-30	40 sec.
1 7/16	6-10	7-45	.....

Total depth of hole, 6 ft. 11½ ins.
Total time, incl. changing steels, 7 mins. 45 sec., = 0.90 ft. per min.
Total time, excl. changing steels, 6 mins. 30 sec., = 1.07 ft. per min.

SECOND TEST.—Tunnel No. 37, North Heading

Large Drill, No. 9, First Run.

Diam., ins.	Time of drilling, mins.	Amount drilled, ins.
2¾	2½	16
2 9/16	2½	14
2⅜	3¼	15
2 1/16	3½	15
2	5¼	27
	16¾	7 ft. 3 ins.

Incl. changing steels, 36¼ mins. = 0.20 ft. per min.
Note.—Back flat hole. Five steels used.

Large Drill, No. 9, Second Run.

Diam., ins.	Time of drilling, mins.	Amount drilled, ins.
2¾	2½	10
2 9/16	3½	20
2⅜	4½	15
2 1/16	5½	19
2	3¼	32
	19¼	8 ft.

Incl. changing steels, 29¼ mins. = 0.27 ft. per min.
Note.—Down cut hole, 40° from horizontal. Five steels used.

Very Hard Rock.

Small Drill, No. 7, First Run.

Diam., ins.	Time of drilling, mins.	Amount drilled, ins.
1⅝	5	20
1⅝	5¼	33
1½	5½	30
	16	6 ft. 11 ins.

Incl. changing steels, 19½ mins. = 0.41 ft. per min.
Note.—Flat back hole. Steel too dull to drill well after first 15 ins. of each steel. Three steels used.

Small Drill, No. 7, Second Run.

Diam., ins.	Time of drilling, mins.	Amount drilled, ins.
1⅝	7½	20
1⅝	4½	34
1½	3½	30
	16	7 ft.

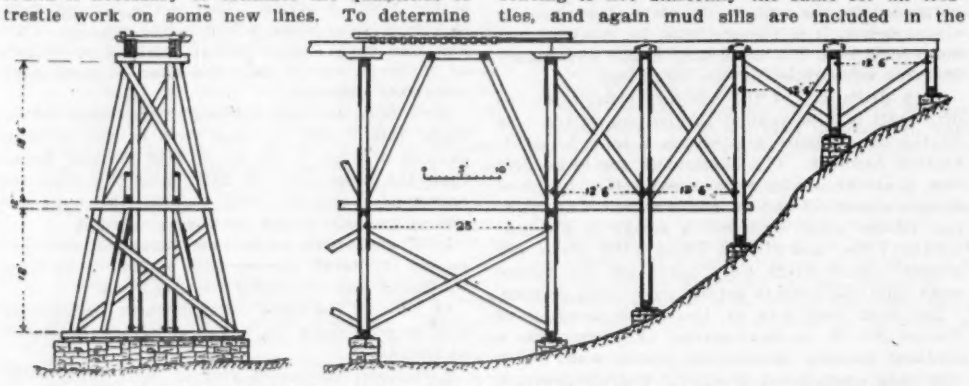
Incl. changing steels, 19½ mins. = 0.36 ft. per min.
Note.—Side cut down hole, 20° from horizontal. Changing steels, 1st 25 sec., 2d 50 sec. Three steels used. Steel too dull to drill well after first 20 ins. of each. Quantity of steel being limited, were obliged to run each full length. Air pressure at drill, 95 lbs. steady.

The cost of repairs from January 1, 1909, to March 10, 1909, on three Leyner drills in the south end of the Elizabeth Tunnel, in gneissoid granite, averaged 47 cts. per drill per lineal foot of tunnel. This tunnel runs 4.3 cu. yds. per lin. ft. The repair costs on the small drill cannot be exactly stated, but they are known to be less.

A Method of Estimating Quantities in Timber Trestles.

By EMILE LOW,* M. Am. Soc. C. E.

In making preliminary estimates for railway construction, it is often advantageous to have recourse to empirical formulas to be used in estimating quantities. There are a number of such formulas for estimating the weight of iron (steel) bridges, which are deduced or based on the actual weight of constructed bridges. Some years ago, while the writer was engaged in railway construction in the State of Virginia, he found it necessary to estimate the quantities of trestle work on some new lines. To determine this by plotting bents, calculating quantities of timber in each, in the stringers, ties, etc., would have entailed considerable work. At the time on other work a large number of trestles had been erected, the exact quantities of timber in each was known, the type of the trestles used being that shown in the accompanying figure.



TYPICAL TIMBER TRESTLE FROM WHICH "ESTIMATING FACTOR" WAS DEDUCED.

Where the height is under 35 ft. the bents are spaced 12.5 ft. c. to c., over that height they are 25.0 ft. c. to c. The general dimension of timber used was 12 × 12 ins. for the posts, sills, caps, etc., and 3 × 12 ins. for the bracing, with odd sizes for other parts. From the explicit data at hand, a profile of each trestle was drawn to a scale of 40 ft. = 1 in., both horizontal and vertical. This profile, of course, also showed the grade line as well as the ground line. From this data the exact area of the trestle profile was computed. This area divided into the quantity of timber contained in the trestle, gave a factor showing the ft. B. M. per sq. ft. of area. Suitable tables were prepared, one for the 12.5 spans, another for trestles having both 25.0 and 12.5 ft. spans. In the accompanying tabulation the trestles were placed in the order of their size (total ft. B. M.), the largest first and the smallest last. For the trestles with all 12.5 ft. spans, the ratio ranged from 8.8 to 11.9 ft. B. M. per sq. ft. of area, the average for 16 trestles, containing 946,910 ft. B. M., being 9.1.

By referring to Table I., it will be noted that this average applies pretty well for all trestles containing over 50,000 ft. B. M., and over 200 ft. in length. The notable exception is trestle No. 30. This is a long trestle, 425 ft., and a comparatively low one, the average height being only 16 ft. It is likely that an earth embankment would have been built here for the same cost.

However, the main reason for the variation of the "factor" is the fact that the sway and other bracing is not uniformly the same for all trestles, and again mud sills are included in the quantity of ft. B. M. All bents, except bank bents, were built on masonry footings, consequently trestles with many bank bents would have relatively larger quantities.

It might have been more advisable to divide the 12.5 ft. spans into two groups, one above 50,000 and the other below 50,000 ft. B. M., thus obtaining a "factor" giving closer results. However, as determined, the variation from actual quantities is not over 10% for the greatest difference, which is certainly near enough for preliminary estimates.

For the 25.0 span trestles, the factor ranges from 7.1 to 9.5 per sq. ft. of area, the smaller where the 25.0 ft. spans predominate, as all of these trestles also contained some 12.5 ft. spans, these at each end. An average for 10 trestles gives 7.7 ft. B. M. per sq. ft. of area.

It will be noted that height influences the factor more or less. This is apparent from trestles Nos. 25 and 15, which contain approximately the same amount ft. B. M. timber, but the maximum heights are 53 and 39 ft. respectively. It is possible that a "factor" could be obtained from a formula which would include with the area, the length of the trestle and also the average height.

If other engineers have formulas on this subject, it would be well for the benefit of the profession to have them published.

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TABLE I.—FACTOR FOR ESTIMATING QUANTITIES IN TIMBER TRESTLES.
(Data of 16 Trestles Actually Built to Obtain "Factor," Ft. B. M. per Sq. Ft. of Profile Area.)
(All bents, 12.5 ft. c. to c.)

Trestle No.	Spans Ft. 12.5	Spans Ft. 25.0	Total.	Maximum Height.	Length.	Ft. B.M. Timber.	Area of Profile Sub-grade and ground.	Ft. B.M. per Sq. Ft. Area.	Cu. Yds. Masonry in Footings.	Average Height.
12	49	..	49	34	612.5	138,701	14,960	9.3	283	25
26	32	..	32	31	400	96,163	10,380	9.2	282	27
30	34	..	34	25	425	78,800	6,650	11.9	217	16
17	25	..	25	31	312.5	72,202	8,170	8.8	235	27
1	24	..	24	32	300	71,841	7,550	9.5	145	28
11	25	..	25	29	312.5	69,446	7,025	9.9	193	24
13	24	..	24	31	300	68,207	7,350	9.3	172	25
16	26	..	26	27	325	67,718	7,350	9.2	230	23
31	21	..	21	29	262.5	59,920	5,800	10.3	143	23
4	19	..	19	32	237.5	55,695	5,800	9.6	105	26
2	16	..	16	27	200	41,138	3,775	10.9	110	20
9	14	..	14	35	175	39,708	3,650	10.9	60	22
19	13	..	13	30	162.5	30,497	2,700	11.3	66	17
20	11	..	11	23	137.5	25,276	2,560	10.0	73	20
21	9	..	9	26	112.5	21,565	2,125	10.1	54	20
22	6	..	6	22	75	9,973	8,700	11.5	15	13
..	..	..	..	...	.....	946,910	104,545	9.1		

TABLE II.
(Data of 10 Trestles Actually Built.)
(Bents, 12.5 and 25 ft. c. to c.)

14	21	17	38	49	487.5	194,562	27,445	7.1	301	40
29	14	13	27	61	500	136,704	18,200	7.5	323	39
25	21	9	30	53	487.5	118,872	15,400	7.7	217	32
15	24	7	31	39	475	117,753	13,600	8.7	267	30
27	12	7	19	59	325	98,750	13,441	7.3	82	44
18	12	7	19	56	325	96,462	13,430	7.2	163	42
6	18	5	23	45	350	86,995	10,590	8.2	207	31
28	9	8	17	39	312.5	74,450	8,900	8.4	107	30
7	19	2	21	40	287.5	67,739	7,700	8.8	156	27
5	12	1	13	35	175	39,930	4,200	9.5	57	26
..	..	..	..	..	....	1,032,217	132,906	7.7		

Notes From Engineering Schools.

McGILL UNIVERSITY.—Although the Department of Applied Science of McGill University has been organized over 30 years, there has never been a reunion of its graduates. On April 27, 28 and 29, of this year, it is planned to have a grand reunion of all classes of this department. On April 30 is the "Convocation of the Faculties of Arts and Applied Sciences," corresponding to the American college commencement. On April 27 the new Macdonald Engineering Building will be formally opened. On the following day the graduates' banquet is the principal function and on April 29 are the class dinners.

UNIVERSITY OF ILLINOIS.—A public health conference is to be held at the University (Urbana, Ill.) on April 23 to discuss questions connected with the organization and administration of public health affairs. It is under the direction of Dr. Edmund J. James, President of the University, and Dr. Geo. W. Webster, President of the State Board of Health. Prof. Wm. T. Sedgwick (Massachusetts Institute of Technology) will take part in the proceedings, and during the week he will deliver at the university a course of six lectures on science in the service of public health. The subjects of his lectures will be as follows:

1. Biology in the service of public health, including bacteriology, microscopical examinations of milk and food supply.

2. Medicine in the service of public health. study of trichnosis, typhoid fever, Asiatic cholera, toxins and antitoxins and vaccination.

3. Chemistry in the service of public health. Early theories of fermentation. Gas supply and public health, sewer gas, ventilation and water sewage.

4. Engineering in the service of public health. Modern water supply, modern sanitary engineering, water sheds, sand filters, disposal of garbage.

5. Statistics in the service of public health. Comparative mortality as to science, mortality from disease, occupational diseases.

6. Education and government in the service of public health. Hygiene and sanitation in the public schools and colleges and universities. Federal bureau of public health, state board of health.

A School of Mines at the University of Illinois is being advocated, in view of the fact that Illinois is the second largest coal producing state in the country, and that better methods of mining are needed for the protection of the workmen and for the economical recovery of the coal resources. The Illinois state legislature is to be petitioned to provide for the establishment of a department of mining engineering or a school of mines at the university. The Western Society of Engineers has taken the matter up, and a committee has been appointed by the President (Mr. Andrews Allen) to present the matter to the state legislature. This committee is composed of prominent engineers, as follows: A. Bement (Chairman), F. A. Delano, Bion J. Arnold, John M. Ewen, Isham Randolph and Robert W. Hunt.

UNIVERSITY OF MINNESOTA.—The officers of the School of Mines are endeavoring to secure the reservation of sufficient water from the Mississippi River, between St. Paul and Minneapolis, to enable the University to build a 2,000-KW. hydro-electric station. This will form a part of the 18,000 to 25,000 HP. which it is hoped to make available at these cities. There is local agitation to have the lower of the two government dams, here, raised and a commission is reported to be investigating the feasibility of the plan.

A NITROGLYCERIN FACTORY at Gordon, Ill., was demolished by an explosion April 15 and two men were killed. The plant was the property of the Independent Torpedo Co.

A SAN FRANCISCO LODGING-HOUSE FIRE April 16 resulted in the death of about twelve of the inmates, while six others were severely injured. The building was a three-story frame structure known as the St. George Hotel. It was situated at Howard and Eighth Sts. There were 180 laborers housed in the hotel at the time of the fire. The property loss is placed at $125,000.

WIND PRESSURE WRECKED A BRICK BUILDING in Camden, N. J., April 13, burying seven workmen under piles of bricks. The walls of the two-story building had just been completed when the front and rear walls collapsed. The accident is ascribed to the walls being subjected to high wind pressure before the mortar had time to set.

RAILWAY ACCIDENT BULLETIN No. 30, just issued by the Interstate Commerce Commission for October, November and December, 1908, gives the number of persons killed in train accidents during that period as 184. The number of injured was 2,924. When accidents other than train wrecks are included, such as accidents to employees while at work and to passengers in getting on or off cars, the total number of casualties is brought up to 17,644 (798 killed and 16,846 injured). This shows a decrease of 2,814 in the total number of casualties as compared with the figures reported for the same quarter in 1907.

The total number of collisions and derailments in the period covered by the present bulletin was 2,684, showing a decrease of 1,280 as compared with the corresponding quarter in 1907. Of the 1,373 collisions and 1,311 derailments, 206 collisions and 130 derailments affected passenger trains. The total damage to cars, engines and roadway amounted to $1,940,133. The figures given in the bulletin are compiled from reports made to the Interstate Commerce Commission by the railway companies.

STATE CANALS IN OHIO are to be investigated by a bi-partisan commission of four men, to be appointed by Gov. Harmon. The commission is to make a thorough investigation and report whether the state should abandon its canals or retain and improve them. The present state canal system carries so little traffic that it is practically useless. The maintenance of the channel, feeders and reservoirs injures much valuable land, so that residents along the line of the canals have at times destroyed some of the reservoirs.

THE PUBLIC BATHS OF BOSTON gave about three-quarters of a million baths in 1908. These were distributed through the year with remarkable evenness, the average having been 65,000 per month, against a maximum of 73,000 in June and a minimum of 54,000 in February. Of ten bathing places open to the public, two are bath houses, six are gymnasiums, and two are schools. The baths in the school buildings are open evenings, only. These figures were taken from the Monthly Bulletin of the Statistics Department of Boston (Edward M. Hartwell, Secretary) for the last quarter of 1908.

THE HAUSER LAKE DAM, near Helena, Mont., reported recently as having been damaged by floods while under reconstruction, was not injured at all, according to a statement which we have received from the Stone & Webster Engineering Corporation, of Boston. Our informant states:

> The facts are that about 150 ft. of a temporary flume which had been built to carry the water around the site of the new dam has gone out, together with a small part of a diverting dam built to turn the water into this flume. The money loss is insignificant, the only effect of importance being that active work on the reconstruction will be postponed until after the high water in June or July.

THE LONGEST CONCRETE ARCH so far attempted is the 280-ft. span of the 708-ft. concrete bridge now being built to carry Detroit Ave. over Rocky River at Cleveland, Ohio. The bridge comprises the main arch, with a span of 280 ft., approached on one side by two and on the other side by three 50-ft. arches. It has a 40-ft. roadway and two 8-ft. sidewalks and is designed to carry on two tracks 60-ton electric cars. The main arch consists of two ribs, 34 ft. c. to c., each 18 ft. wide and 6 ft. thick at the crown and 22 ft. wide and 11 ft. thick at the spring. No reinforcement is used in the arch ribs proper but the floor system, which is carried upon spandrel columns and arches, is reinforced with I-beams and rods. In design and location the bridge resembles the Walnut Lane Bridge in Philadelphia, but is some 47 ft. longer in the span of the large arch. The bridge was designed under Mr. A. B. Lea, Engineer of Cuyahoga County. The contractor is the Schilinger Bros. Co., of Columbus, Ohio, for whom Mr. Wilbur J. Watson is Engineer.

A BRANCH OFFICE of the U. S. Geological Survey was opened on April 1 at Denver, Colo., to facilitate the Western work and to provide a base of supplies for the large corps of engineers which is kept in this field many months each year, studying mineral deposits, conducting topographic surveys for the base maps of the geologic atlas of the United States, mapping the national forests, investigating surface and underground waters and collecting statistics of mineral production.

By this move it is hoped also to meet the need of the Western people for a source of information less remote than Washington. A supply of copies of the publications, available for free distribution, will be kept on hand as well as a complete file of the topographic maps, geologic folios and other publications of the Survey subject to sale. All of these publications will be open to inspection by persons desiring information concerning the subjects treated. Prospective purchasers of maps and folios will be referred to the nearest sales agent, and the free publications will be distributed in Denver to those making application. This office is in the Commonwealth Building.

AUTOMATIC GAS COMPRESSORS for high-pressure gas distribution are being placed on the market by the Westinghouse companies. It is claimed that the use of these compressors involves no complication of the station apparatus and only a small capital outlay. The standard types of air compressors, common in steam and electric-railway service, have been used with little change. These are driven by steam or by electric current, and are set up so as to draw low-pressure gas from the gasometer and to deliver it, through some sort of a storage reservoir, to the high-pressure mains. The governors of these compressors may be adjusted for a constant pressure or for raising the pressure to a certain maximum and allowing it to drop to a fixed minimum.

Personals.

Mr. Ira J. Owen, of Chicago, consulting mechanical engineer and expert in factory engineering, announces the removal of his office to 856 First National Bank Building, Chicago.

Mr. J. M. Farrin, formerly an Assistant Engineer of the Missouri Pacific Ry. at St. Louis, Mo., has been appointed Engineer of Bridges and Buildings of the Cuba R. R., with headquarters at Camaguey, Cuba.

Col. John G. D. Knight, Corps of Engineers, has been appointed to be brigadier-general to succeed Gen. W. H. Carter, who will become major-general upon the retirement of Major-Gen. J. F. Weston, Nov. 13.

Mr. J. G. Seyfried has been appointed Structural Engineer of the Grand Trunk Ry., with offices at Montreal, Canada. He has been for several years assistant to the late J. W. Schaub, who was consulting engineer for much of the special bridge work of the Grand Trunk Ry.

Mr. Charles H. Preston, Jr., Assoc. M. Am. Soc. C. E., Resident Civil Engineer for the New York, New Haven & Hartford R. R. Co. for the past four years on improvements at Waterbury, Conn., will withdraw from that position April 23 to open an office in Waterbury for general practice as a civil engineer and surveyor.

Mr. C. W. Bradshaw, Division Superintendent of the Louisville & Nashville R. R., at Etowah, Tenn., has been transferred to Louisville, Ky., to fill the vacancy caused by the death of Colin A. Davies. Mr. Bradshaw will be succeeded at Etowah by Mr. A. B. Bayless, formerly Assistant Superintendent of the same division.

Mr. James MacMartin, Chief Engineer of the Delaware & Hudson Ry., has resigned that position, effective May 1, to become Vice-President and General Manager of the Elmore & Hamilton Contracting Co., with offices in the Tweddle Bldg., Albany, N. Y.

Mr. S. D. Warriner, M. Am. Inst. M. E., General Manager of the Lehigh Valley Coal Co., has been made Vice-President of that company to succeed William H. Sayre, who died April 7. Mr. Warriner's official title is now Vice-President and General Manager.

Mr. J. Francis Le Baron, M. Am. Soc. C. E., Chief Engineer of the Sumas Development Co., Ltd., of Vancouver, B. C., has been also appointed Consulting Engineer of the Hatzic Lake Reclamation, comprising 4,000 acres of lake bed and lands overflowed 18 ft. at high water by the Fraser River.

Obituary.

A. M. Gilbert, President of the Buda Foundry Co., of Chicago, died recently at Santa Barbara, Cal.

Joseph Russell Jones, who was the first president of the Chicago West Division Ry., died April 11 at his home in Chicago, Ill. Mr. Jones was born at Conneaut, Ohio, in 1823. From 1869-75 he was U. S. Minister to Belgium.

Langley L. Sagendorph, President of the New York Iron Roofing & Corrugating Co., of Jersey City, N. J., died April 13 at Philadelphia at the age of 67 years. He was one of the earliest promoters of the sheet metal industry in this country.

James M. Thomson, Vice-President of the Thomson Bridge Co., was killed by a robber April 17 in San Francisco, Cal. Mr. Thomson had just returned from a bank with money for the bridge company's payroll, amounting to $3,200, and was shot twice by two men who had overpowered the bookkeeper during his absence. The robbery took place at noon in the heart of the wholesale district. One of Mr. Thomson's assailants was captured and the money was recovered.

Joseph C. Meredith, Chief Engineer of the Florida East Coast Ry. extension across the Florida Keys, died April 20 at Miami, Fla. Mr. Meredith was born in Rushville, Ind., in 1856 and took the course in mechanical engineering at the Iowa State College, graduating with the class of 1878. He afterward attended the Stevens Institute of Technology. From 1881 to '87 he was an assistant engineer on the Missouri River improvements and from 1893 to '96 he served as a division engineer on the Missouri River Commission. Previously to entering the service of the Florida East Coast Ry. in 1905, he had been employed on the construction of the Mexican Central Ry.

Lewis F. Rice, M. Am. Soc. C. E., died April 13 at his home in Brookline, Mass. Mr. Rice was born at Boston, Mass., in 1839. He spent seven years in the Boston public schools, one year at West Point and graduated at the Rensselaer Polytechnic Institute in 1858. From 1858 to '59 he served as an engineer on the construction of the Brooklyn (N. Y.) water-works and in 1860-1 he was a division engineer of the Troy & Greenfield R. R. During the Civil War he served in the 31st Massachusetts Volunteers as a lieutenant, colonel and major. At the close of the war, Mr. Rice practiced as a civil engineer in Boston until in 1867 he became Assistant Engineer of the Reading & Columbia R. R. He left this position the same year to become Assistant Engineer of the St. Louis (Mo.) water-works, where he remained till 1871. From this time he conducted a general practice as an architect and civil engineer in Boston until 1899 when he became Assistant Engineer and Architect of the American Bell Telephone Co., a position which he retained up to the time of his retirement last June.

Andrew Rosewater, M. Am. Soc. C. E., City Engineer of Omaha, Neb., died April 17 at the Paxton Hotel in that city from heart disease. Mr. Rosewater was born in Bohemia in 1848 and was educated in the schools of Cleveland, Ohio. He was employed from 1864 to '68 in the engineer corps of the Union Pacific Ry. and became, in the latter year, Assistant City Engineer of Omaha. In 1870 he was advanced to be City Engineer of Omaha and held this position until 1876, when he acted for a year as Manager of the Omaha "Bee," which was founded by his brother, Edward Rosewater, who died in 1906. In 1878 he became Engineer in charge of construction of the Omaha & Northwestern Ry. and was subsequently Resident Engineer of the Omaha water-works, 1880-1; City Engineer of Omaha, 1881-7; Consulting and Designing Engineer of sewerage for 25 different cities, 1887-91; President of the electrical subway commission of Washington, 1891-2. Since 1897 Mr. Rosewater has again been City Engineer of Omaha. A fuller account of his career will be given in our next issue.

Frederic A. W. Davis, whose death at Pelham, N. Y., April 9, was briefly noted in our last issue, was born Sept. 24, 1836, at Jackson, Mo., and went to Indianapolis, Ind., in 1852, seeking employment. His first ambition was to become a machinist, but he was unable to find that kind of work and so accepted employment as clerk in the store of John M. Talbott, one of the then prominent Indianapolis stores, and remained in this position for some time. He left this store to take up bank work, and continued in this line, in various capacities, for several years. During the Civil War, as officer of one of the banks, he handled all of the money with which the Indiana soldiers were paid, and was instrumental in maintaining the credit of the state during the war times. From 1865 to '81 he was Cashier of the Indiana Banking Co., and his connection with the Indianapolis Water Co., which began in 1881, was brought about by the relation he had borne to the Banking Co. Among the assets of that company was considerable stock in the water company, and also some of its bonds, all of which were turned over to Mr. Davis that he might do with them the best that was possible for the creditors of the bank. He became Vice-President and Treasurer of the Indianapolis Water Co., which had been in serious financial condition, and continued in these capacities until five years ago, when he was elected President, to succeed the late Gen. Thomas A. Morris; he was also at that time re-elected Treasurer, and held these positions at the time of his death. Mr. Davis became a recognized authority on all matters pertaining to water-works and his advice was sought by a large number of water-works plants throughout the country.

While a man slight of frame and not constitutionally strong, his energy was the wonder of all who knew him, and his application to business left him no time for recreation. With everything that in any way touched the business or operations of his company, he gave himself the familiarity of an expert.

Mr. Davis was President of the American Water Works Association in 1896-7, an active member of the New England Water Works Association, the National Con-

servation Commission, the Lakes-to-the-Gulf Deep Waterway Association, the Indiana Engineering Society, and many other kindred associations.

Amzi L. Barber, F. Am. Soc. C. E., President of the Barber Asphalt Paving Co. since 1883 and of the Trinidad Asphalt Co. since 1888, died April 18 at Ardsley Park, N. Y. He was born at Saxton's River, Vt., in 1843, and graduated at Oberlin College in 1867. He later received the degree of LL. B. at Columbia University and was at one time Professor of Natural Philosophy of Howard University, Washington, D. C.

His connection with the asphalt business began in 1878 when he took contracts for laying pavements in the District of Columbia. In 1883 he incorporated the Barber Asphalt Paving Co. and began the negotiations which led to his obtaining from the British government in 1887 a 42-year concession for taking asphalt from the Trinidad asphalt lake.

In the following year Mr. Barber organized the Trinidad Asphalt Co. The aggregate capital of this company and the original Barber company is given as $4,000,000. In 1894 he acquired the New York and Bermudez Co. and thus gained control of extensive properties in Venezuela, including the Bermudez pitch lake. The Barber companies were included originally in the asphalt "trust," the Asphalt Co. of America, founded in 1899; but two years later, when this company was sold to the National Asphalt Co., Mr. Barber resigned the presidency and held himself aloof from all connection with the last-named company. When the National company went into the hands of receivers in 1903 and was reorganized as the General Asphalt Co., the original Barber companies remained intact.

Mr. Barber had meanwhile taken up asphalt properties in Mexico and, in conjunction with Ambrose H. Carver, organized the Pan-American Asphalt Co., but the Mexican properties were never worked. In 1904, soon after the formation of the Pan-American Co., the trouble began in Venezuela between President Castro and the New York and Bermudez Co., as a result of which Mr. Barber was accused by the trust of conspiring with President Castro to wrest from it the Bermudez pitch lake.

The Locomobile Co., one of the first concerns in this country to manufacture automobiles, was organized by Mr. Barber in 1897. He was also one of the first to utilize the steam turbine on a yacht, and the U. S. converted yacht "Yankton" was formerly owned by him under the name "Sapphire III."

Mr. Barber is survived by his wife, formerly Miss Julia L. Langdon, of Elmira, N. Y., who was a cousin of Mrs. Samuel L. Clemens, and by two daughters, Mrs. Samuel T. Davis, Jr., whose husband is President of the Locomobile Co., and Mrs. Chas. T. St. Clair, of Washington, D. C. His only son died about four years ago.

Chambers McKibbin Craig, Ph. B., C. E., a member of the class of 1875, Sheffield Scientific School, committed suicide by shooting himself through the head with a Colt's revolver of heavy caliber in his apartments at 66 Madison Ave., New York City, on the evening of April 5, 1909. An intimate friend of Mr. Craig has contributed the following obituary notice:

There is every reason to believe that, previous to his death, Mr. Craig, though in bad health, had full possession of sound reasoning faculties, that his act was deliberate and long premeditated. He left an exact statement of his financial condition, his debts were all paid and his belongings were disposed of in a most careful, orderly and systematic manner. Persons who had been with him only a few hours before his death were unable to recall the slightest change from his usual demeanor. In a letter written some weeks before, with reference to a proposed trip to Italy, he made the now significant statement: "I think a different line of travel will suit me better."

A letter to his wife, who was in Atlantic City at the time of his death, furnished the only clue to the cause of the tragedy. It was evidently Mr. Craig's intention that no other person should know the contents, but, under authority of a recent enactment, the letter was opened by the coroner and published far and wide long before Mrs. Craig herself had seen it. All the published copies were incomplete and some of them very incorrect. The original stated very clearly that Mr. Craig's fortune, greatly reduced by extravagance for which he was not personally responsible, was no longer sufficient to properly maintain his wife and himself and that, consequently, self obliteration seemed to be the only way to insure her future support. This view will not seem so extraordinary when we reflect that he was sick, crippled and utterly unable to begin over again the struggle for existence.

He was a man of unexceptionable habits and character, beloved by a host of relatives and friends, simple in his tastes and manner of living, moderate in every kind of personal indulgence, fond of a quiet domestic life and one who could rarely be induced to participate in any of the frivolities common among ultra fashionable people. His dominant characteristics were love of an active, useful life, an almost quixotic idea of what honor required in his dealings with others and extreme reticence in regard to his domestic affairs and business. His comparatively idle life during recent years was forced upon him by ill health and was not the result of choice.

Mr. Craig was a member of the American Society of Civil Engineers; was for some years employed by the Coast and Geodetic Survey at New Haven, Philadelphia and on the lower Mississippi; was an assistant engineer on both the Mexican National and Mexican Central railways; served under Lesseps at Panama; was Chief Engineer of a railway in Georgia and filled with credit many other positions of responsibility.

During the year 1899 he took care of a relative afflicted with malignant cancer, completely disregarding all the precautions usually observed by attendants in such cases. The excruciating torture he then witnessed gave him a horror of that particular disease which never left him afterwards. In talking with a brother, he subsequently remarked that he would not hesitate a minute to take his own life, if similarly afflicted. By a strange coincidence his health, previously good, began to decline from that time. Though his real trouble was believed to be ulceration of the stomach, he was constantly apprehensive that he had the only disease which he greatly feared. It is not impossible that actual suffering, combined with these apprehensions of still greater torment in the future, may have done much to influence his conduct.

During the years in which bad health unfitted him for active service, he traveled extensively in this country, the West Indies and Europe. While at Kingston, Jamaica, some time ago, the carriage in which he was riding was overturned, dislocating his shoulder and breaking his collar bone. Before he had even partly recovered from this accident the earthquake came and he was in the wreck of the Myrtle Bank Hotel where many persons were killed. The dislocation and fracture received no proper attention until his return to New York, and it was then too late to repair completely the injury sustained.

Mr. Craig was in his 55th year at the time of his death and had no children. The funeral services were held in the Church of the Incarnation on Madison Avenue, April 8, and his body now rests in the Woodlawn Cemetery.

Engineering Societies.

COMING MEETINGS.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.
April 27 to 30. Annual meeting at Louisville, Ky. Secy., H. D. Vought, 95 Liberty St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 4-7. Spring meeting at Washington, D. C. Secy., Calvin W. Rice, 29 West 39th St., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 6-8. Annual meeting at Niagara Falls, Canada. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AIR BRAKE ASSOCIATION.
May 11-14. Annual meeting at Richmond, Va. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 18-20. Annual meeting at Cincinnati, Ohio. Secy., Richard Moldenke, Watchung, N. J.

AMERICAN RAILWAY ASSOCIATION.
May 19. Annual meeting at New York City. Secy., W. F. Allen, 24 Park Place, New York City.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 25-27. Annual meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 1-4. Annual convention at Atlantic City, N. J. Secy., W. W. Freeman, 29 West 39th St., New York City.

AMERICAN WATER-WORKS ASSOCIATION.
June 8-12. Annual convention at Milwaukee, Wis. Secy., John M. Diven, 14 George St., Charleston, S. C.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 16-18. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 21-23. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 39 Old Colony Bldg., Chicago, Ill.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
June 21-23. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, C. & E. I. R. R., 327 La Salle Station, Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 23-25. Annual meeting at Detroit, Mich. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 24-25. Semi-annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 28. Annual convention at Frontenac, N. Y. Secy., Ralph W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 3. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
July 6-9. Annual convention at Bretton Woods, N. H. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

IOWA STREET AND INTERURBAN RAILWAY ASSOCIATION.—The annual convention will be held at Cedar Rapids, Iowa, April 22-24. The secretary is Mr. L. D. Mathes, Dubuque, Iowa.

BROOKLYN INSTITUTE OF ARTS AND SCIENCES.—Under the auspices of the engineering department, Mr. George A. Soper, M. Am. Soc. C. E., delivered a lecture April 16 at the Brooklyn Academy of Music on "The Sanitary Protection of Tidal Harbors."

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At the meeting of the general section held April 15 two papers were read, entitled "Reclamation and Development on the New Jersey Coast," by George L. Watson, and "Railway Construction Notes," by F. Pardoe Wilson.

NEW YORK RAILROAD CLUB.—At the regular meeting of April 16, Mr. Walter V. Turner, of the Westinghouse Air Brake Co., presented a paper entitled "Development in Air Brakes for Railroads, with a Brief Review of Past and Present Operating Conditions."

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—At a special meeting April 16 in New York City under the auspices of the educational committee, a paper was read on "Fundamental Principles of Industrial Education," by Herman Schneider, Dean of the College of Engineering of the University of Cincinnati.

AMERICAN WATER WORKS ASSOCIATION.—The next annual convention of the association will be held at Milwaukee, June 8-12. Since the last convention of the association, a Water Works Manufacturers' Association has been organized, and the latter has appointed a transportation committee to arrange for a special train from New York to Milwaukee for the benefit of the delegates to the above-named convention. Mr. W. H. Van Winkle, of 50 Church St., New York City, is one of the members of this transportation committee, and will be glad to give information regarding the proposed train.

WESTERN SOCIETY OF ENGINEERS.—A joint meeting of the electrical section of the society and the Chicago branch of the American Institute of Electrical Engineers was held April 16 at the society's rooms in Chicago. A paper on "The Electrical Equipment of the Steel Plant at Gary, Ind.," was presented by Mr. B. R. Shover, referring particularly to the use of electric motors of 6,000 HP. for operating the roll trains of the rolling mills.

The first work for this great steel plant was on March 12, 1906, when the survey for the site on a waste of sand was commenced. The harbor was opened and the first cargo of ore unloaded on July 21, 1908, and the first rail was rolled on Jan. 23, 1909. The plant is unique in having been designed in the first place for the most up-to-date equipment on an immense scale (for the present and future), and with no limitations as to the size of site. It was designed also for the use of electric power wherever possible, and in the rail mill there is nothing but electric power. The great motors of 6,000 HP. for this mill were built in place, and are operated practically under power-house conditions, as the motor room is separated from the mill by a brick wall. Special electrical means had to be devised for the prompt stopping of these great motors in case of emergency, but they can now be stopped in from 1½ to 3 minutes.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—During the spring meeting in Washington, D. C., President Taft will hold a reception for the members in the afternoon of May 6 at the White House. On May 5 there will be a special exhibition drill of the U. S. troops at Fort Myer, to which the members and guests will be invited, and at the same time, if conditions are favorable, there will be an ascension of a dirigible balloon and an aeroplane. At the evening session, May 6, Rear-Admiral Geo. W. Melville, Engineer in Chief, retired, U. S. Navy, will give an address on "The Engineer in the Navy," and this will be made the occasion for the presentation to the National Gallery of a portrait of Rear-Admiral Melville, presented by friends and admirers. The presentation will be made by Mr. Walter M. McFarland, of Pittsburg, Pa., and the portrait will be received for the National Gallery by Dr. C. D. Walcott, Secretary of the Smithsonian Institution. Mr. F. H. Newell, Director of the Reclamation Service, will deliver an illustrated address at the evening session, May 5, on "Home Making in the Arid Regions."

The professional papers to be presented are as follows:

May 5.—"A Unique Belt Conveyor," Ellis C. Soper; "Automatic Feeders for Handling Material in Bulk," C. Kemble Baldwin; "A New Transmission Dynamometer," Wm. H. Kenerson; "Polishing Metals for Examination with the Microscope," A. Kingsbury.

May 6.—"Marine Producer Gas Power," C. L. Straub; "Operating System for a Small Producer Gas Power Plant," C. W. Obert; "A Method of Improving the Efficiency of Gas Engines," T. E. Butterfield; "Offsetting Cylinders in Single-Acting Engines," T. M. Phetteplace.

May 7.—"Small Steam Turbines," Geo. A. Orrok; "Oil Well Tests," Edmund M. Ivens; Safety Valve Discussion; "Specific Volume of Saturated Steam," C. H. Peabody; "Some Properties of Steam" R. C. H. Heck; "A New Departure in Flexible Staybolts," H. V. Wille.

Excursions will be made to the navy yard, the museums, the city pumping station and lighting plant and to other places of interest.